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THE ECONOMIC EFFECTS OF ENVIRONMENTAL EXPENDITURES ON THE CONSTRUCTION INDUSTRY

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Between 1978 and 1985, municipal governments and private industry will spend about $111 billion dollars on construction of new facilities to reduce air and water pollution as mandated by the EPA. This report presents estimates of how these projected expenditures will affect the total level of construction and how employment, wages, interest rates, and other variables will respond to the change in construction output. Effects on employment in selected sub-classes of the construction industry were also estimated.

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The results suggest that construction output will rise by less than the EPA mandated expenditure. The difference is due, in part, to displacement of spending that local governments would otherwise have done and, in part, to absorption of the increase by rising wages and prices in construction. There is also some displacement of industrial expenditures for pollution abatement because of the increased cost of building a new plant.

The results also suggest that employment in the construction industry is increased. Employment of young, black, inexperienced workers increases more than would be expected based on their representation in the construction labor force.

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INTRODUCTION

Between 1978 and 1985, industry and municipalities are expected to spend about $111 billion to comply with air and water pollution control laws. Of this amount, 73 percent will be spent by private industry, and 27 percent will be spent by public agencies. Much of the public spending will be made under EPA's construction grants program which provides matching funds for construction of municipal sewer systems.

Whether private or public, a great deal of the spending will be for new construction. We estimate that from 1976 to 1985 about 75 percent of expenditures for reducing industrial pollution, and more than 85 percent of expenditures made under the program of construction grants to municipalities will go directly for construction. Although this is one of the largest public works programs ever undertaken, the added construction demand will not be massive in comparison to total construction; it will amount to only about 5 percent of total construction in 1983 and about 10 percent of nonresidential construction. Yet, it could have important effects on specific categories of construction. Industrial construction mandated by requirements for pollution abatement is predicted, in 1983, to be about 28 percent of total industrial construction. The addition to state and local construction is projected to be about 6 percent of what would have been undertaken otherwise.

This report was commissioned by the Environmental Protection Agency to estimate how the expenditures mandated by pollution control laws will affect the construction industry. Of particular interest are the effects on new construction of specific types, on employment in particular construction trades, on workers with particular characteristics, on construction prices, on construction wages, and on the costs of borrowing. One major issue was whether the added expenditures on construction would be realized in added output or would be absorbed by increases in wages, prices, and borrowing costs. A second major issue was whether local governments and private industry would reduce their own construction to undertake the added construction. A third major issue was whether employment gains would be concentrated among high-wage workers with high seniority or among younger, inexperienced workers.

Determination of how the industry will respond to changing demands involved development and estimation of an econometric model of the construction industry and related markets. This model was used to form what are called BASELINE projections of construction, construction prices, wages, interest rates, and other variables of importance under the assumption of "low" spending on pollution abatement. More specifically, these projections incorporate no expenditures by industry to meet federal standards. For construction grants, funds authorized under the 1972 legislation are included in the baseline, but no funds authorized after that. Once these projections were made, the added construction requirements derived from EPA requirements and grants were added to form forecasts termed ACTUAL. By comparing BASELINE and ACTUAL, the incremental effects could be measured. Both projections were based on the values of a number of variables determined outside the model. The predicted values of these exogenous variables were estimated for EPA by Data Resources Inc.

In some instances, information was needed that was too detailed to be obtained from an aggregate econometric model. In particular, we wanted to know what kinds of workers were employed in construction because of the added construction demand: experienced or inexperienced, young or old, locals or outsiders, white or nonwhite. To obtain this detail, we used the LEED file, a set of data drawn from Social Security records, which provides information on individual workers.

The Econometric Model

The econometric model of the construction industry has 4 sectors: (1) private construction, (2) state and local construction, (3) labor, (4) financial markets. Within each sector is further detail. For example, the private construction sector includes four types of private construction: industrial, commercial, public utilities, and residential.

In the discussion of each sector, we describe first the modeling of demand and its estimation and then the modeling of supply and its estimation. In every case, data sources and the specific measurement of variables used in this analysis are described in detail.

The first sector, private construction, includes equations describing demand for the stock of structures of different types, identities relating these stocks to the demand for new construction, and equations describing how the price of each type of structure is determined.

The sector describing the state and local construction is intentionally divided into unequal categories. One category includes only sewer systems, a major focus of this study. The other category includes all other state and local construction. The equations used to determine price and quantity of state and local construction in these categories are similar to those used in describing the private sector.

The labor sector includes a demand for labor estimated in such a way as to allow prediction of demands for specific trades. These demands depend on the wage relative to the price of new construction, on the amount of new construction (in 1972 dollars), and on the mix of new construction between different types of structure. Equations are also included to describe the determination of wages and unemployment.

The financial sector describes how interest rates are determined for taxable and tax exempt bonds, home mortgages, and short term business loans. These interest rates are explained as functions of expected rates of inflation and liquidity. The level of debt, in turn, depends on investment, one component of which is investment by business and municipalities to abate pollution.

Findings

The added demand for construction because of environmental grants and regulations will range from about $2.2 billion (1972 dollars) in 1978 to about $5.8 billion in 1983. Total constant dollar construction will increase by less (about $1 billion in 1978 and $3.6 billion in 1983) because other construction is displaced. The displacement occurs because of increases in wages and interest rates and because federal construction grants support some projects that the communities would have undertaken on their own. The added demand for construction will raise actual construction by about .8 percent in 1978. In 1983, the increase will be 2.3 percent. These percentage increases would have been greater except that environmental demands displace other construction to some extent. We estimate displacement in 1978 and 1983 as about 1 percent and 1.4 percent, respectively.

Because of the added demand, employment in construction will be about .78 percent higher in 1978 and about 2.4 percent higher in 1983.

Wages also will be increased but not by so much as employment. The largest wage increase is about .8 percent. The price of new construction will be increased by no more than .6 percent, but the increase will be permanent. Interest rates on corporate bonds will be raised by about 1 percent (e.g., from 8.26 to 8.34) in 1982 through 1985. The yield on municipal bonds will be raised by as much as 1.3 percent in this period.

From an analysis of data on individual workers, we are able to describe how an employment change will be distributed among workers with different characteristics. We find that about 33 percent of the increased employment will consist of entry level workers, those with little or no experience; about 33 percent will be workers less than 24 years old; workers already in the community will account for 54 percent of the increase in employment, the rest being accounted for by workers moving in and by commuters. Fourteen percent of the employment increase will be nonwhite workers. The added employment of these groups will be more than proportional to their existing representation in employment.

For a more detailed summary of results, see the "Findings" chapter. A summary organized to facilitate generalization of our results is given in the impact handbook--the last chapter.

THE ECONOMETRIC MODEL

This chapter provides a detailed description of the econometric model of the construction industry and related markets. The description includes background on each sector, the specification of equations to be estimated, the description of data sources, and the results of estimation.

THE CONSTRUCTION MARKET

The construction industry provides a wide variety of products, including houses, industrial plants, office buildings, and other commercial strucuctures, and power plants. Much construction, for example, sewers, dams, highways, and oil derricks, is not buildings at all. What justifies considering construction as an industry despite the variety of products is that the different types of construction use many of the same factors of production. Both residential construction and sewage treatment plant construction make heavy use of carpenters. All types of construction make some use of earthmoving equipment and most projects make some use of concrete.

If construction is counted as a single industry, it is a large one. The value of construction put in place in 1976 was about three times the output of the basic steel industry and about one and one-half times as large as the auto industry. Since 1947, construction output has grown with about the same trend as GNP. In 1947, construction was 8.6 percent of GNP. In 1975, it was 8.7 percent.

Yet the growth of construction put in place has not been steady. Though public construction has grown smoothly, both private residential construction and private nonresidential construction have varied markedly about their trends as illustrated in figure 1.

One explanation for this cyclical variation is that the demand for industrial construction depends not on the level of manufacturing output but on its change.[1]

This derived demand introduces an "acceleration" effect, so that the demand for construction changes much more drastically than changes in manufacturing

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[1] This discussion ignores construction to replace depreciation in the stock of structures, though this depreciation is included in the statistical analysis.

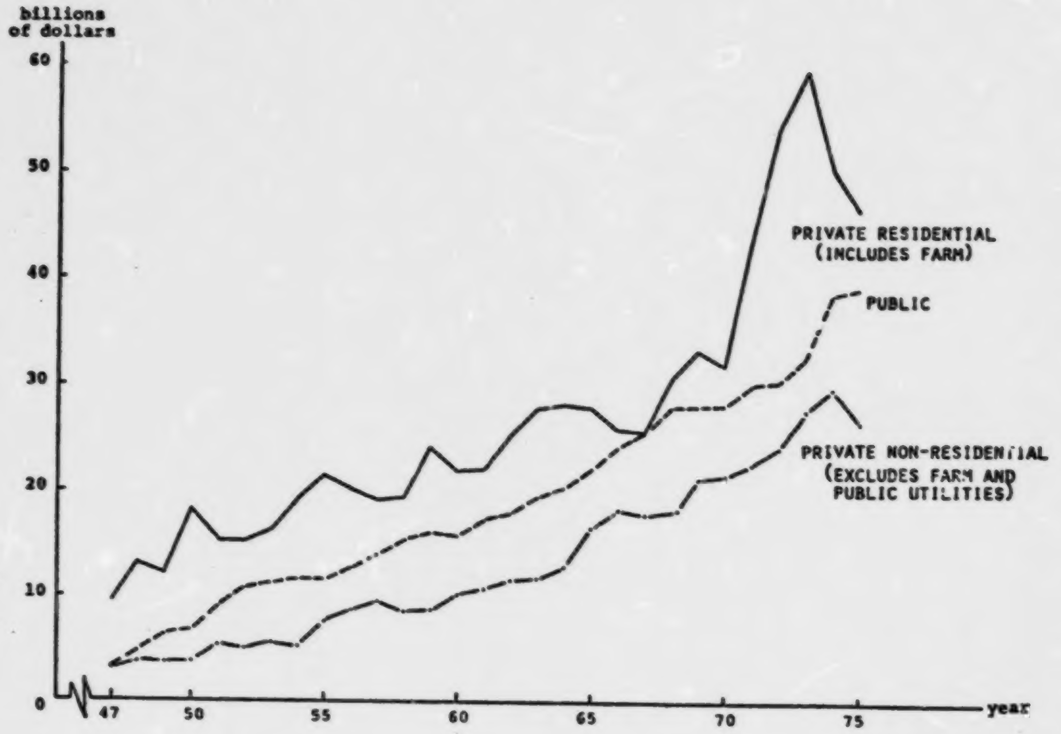

FIG. 1: The Growth of Different Types of Construction, 1947-1975

activity. If industrial production rises in one year, new industrial capacity will be needed, and manufacturers will demand new construction. If industrial production is constant in the next year, the demand for new capacity will drop off to nothing. The cyclical variation of construction activity is reinforced by cyclical changes in interest rates; high interest rates have a well-known dampening effect on demand for new construction, and interest rates typically rise late in a business cycle and remain high through the early stages of recession.

Some caution is called for in interpreting the results of a model such as this one which describes construction as a single, national market. In contrast to manufacturing, construction is a local industry. Only rarely are structures shipped. Prices need not be the same in different localities if certain scarce factors, such as skilled labor, are slow to move. The model describes an average of the behavior of all regions, ignoring any difference between regions.

How Business is Done

Most construction is custom made. The buyer decides on a project, has an architectural-engineering firm design it and designates a general contractor to manage the project. For public projects the general contractor is selected by competitive bidding. For private projects, competitive bidding is common, although, buyers sometimes negotiate directly with a single contractor.[1]

The general contractor is a middleman. He quotes a fixed price for a project, then hires workers or subcontracts parts of the job to firms who actually do the construction. Since his margin is only about 10 to 15 percent of the value of the building, he can easily lose his profit if costs rise unexpectedly or if work drags on much longer than expected. The fixed price suggests that changes in the general contractor's costs will not be passed immediately into changes in the price paid by the buyer. Of course, some allowance must be made for possible future cost increases, such as new wage settlements, but these developments are not known in advance, so whatever adjustments are necessary must be based on forecasts from current costs. When the chance of a labor shortage or large wage settlement is unusually great, general contractors are said to "overcompensate." This means, for example, that if there is a 50-50 chance of a wage increase of 20 percent, the price of the building quoted to the buyer will be higher than what is needed to cover the 10 percent wage increase expected on the average. For a small general contractor, it is easy to understand the overcompensation: he may have great trouble recovering from one large loss.

---

[1] Much of the material in this section is drawn from Stephen Sobotka and Company, and McKee-Berger-Mansueto, Inc., The Economic Impact on the Construction Industry of Additional Demands Caused by New Environmental Protection Standards, prepared for Environmental Protection Agency, Dec. 29, 1972, pp. 16-35.

Because his profit is a relatively small part of the total cost, the general contractor can not, on his own, vary the price sharply in response to demand. Even if his margin drops sharply, the effect on the final price will be small. Therefore, the supply of new construction (defined so as to hold constant the prices of purchased inputs) must be quite elastic. If construction prices are to respond to demand, the prices of inputs must also respond.

The general contractor usually subcontracts part of the building to special trade contractors. These are companies specializing in supplying a particular type of skilled construction worker. Special trade firms include electrical, plumbing, and cement work.

Note that the organization of the construction industry is different from that of manufacturing. In manufacturing, all workers engaged at one site will work for the same firm. In construction, each project will involve a number of independent firms. Largely, this is because structures are not built to standard specifications. Construction firms can not hire a large group of workers to repeat a simple job, as in mass production processes. Instead, they must collect a slightly different work force capable of following unique specifications each time a new project is undertaken. By contrast, the special trades firm can concentrate on a given process for meeting different specifications, thereby reducing the breadth of skills required of each worker and still providing both the worker and the general contractor with the flexibility to meet specifications that vary from project to project.

Degree of Competition

It is difficult to determine whether a given industry is monopolistic, competitive, or falls somewhere in between. There are no definitive tests. The price and output of a monopolist will look, to the outsider, much like that of a perfect competitor. Characterizing an industry as monopolistic or competitive provides an interpretation of the industry's actions but is not of great use in predicting how it will behave. Throughout this study, the assumption of competitive markets will be used as a maintained hypothesis.

The competitive hypothesis is consistent with available evidence. If concentration is measured as the share of output produced by large firms, construction must be counted as one of the least concentrated of American industries. Small firms with fewer than 10 workers account for more than 20 percent of the business, and the median firm size is less than 50 workers.

One intuitively appealing indicator of competition is the degree to which the industry is made up of corporations. Most construction firms (78 percent in 1973) are sole proprietorships and partnerships, though the share of corporations is growing. While the corporations are much larger and hence account for a disproportionate amount of the business, the role of proprietorships is much larger here than in manufacturing.

Another indicator of the degree of competition is the rate of entry and exit. From 1972 to 1973 when output grew by 1.5 percent, the number of firms in contract construction grew by 8 percent.

The average firm size, the importance of sole proprietors and partnerships, and the rate of entry and exit suggest that the construction industry is competitive. Even if the small firms are large relative to the size of their local market, factors of production can move and firms can accept jobs outside their base area. Local monopolies seem unlikely to persist.

The degree of concentration in construction differs by subindustry. The firms likely to build sewer lines and sewage treatment plants are in relatively concentrated subindustries of construction. In construction as a whole, small firms (those with fewer than 10 employees) account for over 20 percent of the business. In subindustry 1623, which includes sewer line construction, the corresponding figure is less than 10 percent. In subindustry 1629, which includes construction of sewage treatment plants, only 4.9 percent of the business is done by small firms.

There may also be relatively few firms capable of working on large public projects. When a contractor undertakes a large project, he must put up a performance bond which excludes bidders of limited assets. The bond ensures that there will be enough money to finish the project if the general contractor becomes bankrupt before the project is done. Few firms have enough credit to put up the necessary bond for a large project.

All things taken together, the numbers indicate that the construction industry is competitive, but the parts of the industry that make sewers and treatment plants may be less so. Still, there is no way of knowing how competitive the specific subindustries are. It is not even clear that imperfect competition can exist in the subindustries; after all, resources are mobile, and if a large firm is required, smaller firms can combine. Moreover, there is no clear evidence that an industry of large firms acts differently from an industry of small firms. Therefore, we proceed as if the industry is competitive.

THE DEMAND FOR STRUCTURES: PRIVATE

In this section we describe the derivation of equations for the demands for different types of structures. The demand equations will later be estimated using annual date series data. Subsequent sections describe the data used for estimation and the results.

The demand equations are derived from the assumption that structures are intermediate products used in a production process. The demand for new structures is derived from the change in this stock and the rate of depreciation.

Because structures are considered intermediate goods, the functional form of the demand curve follows from the explicit production function and the assumption about the behavior of firms. We assume that the production function of products using structures as inputs is described by a constant elasticity of substitution production function.

We assume too that firms choose their desired level of input use so as to maximize profits, taking as given the prices of inputs and output. These assumptions result in an equation for the desired quantity of structures. This equation is then modified to reflect gradual adjustment of the actual to the desired stock.

The desired stock and the adjustment mechanism are described in the following two equations:

Desired Stock of Structures

$$\log(K_i^*) = \alpha + \beta \log(Q_i) + \gamma \log(P_i/V_i) + \delta \log(X_i) \quad (1)$$

where

K_i^* = the desired stock of structure i at the current period

Q_i = the output of the production process using structure i as an input

P_i = the price of Q_i

V_i = the user cost of structure i, described more fully below

X = other exogenous variables

Partial Adjustment[1]

$$\log(K_i) - \log(LK_i) = \lambda[\log(LK_i^*) - \log(LK_i)] \quad (2)$$

where

K_i = the actual stock of structure i

LK_i = the stock of structure i one year earlier

LK^* = the desired stock of structures one year earlier

The demand for structures, taking into account gradual adjustment, is the combination of (1) and (2) above. Equation (3) describes this demand.

---

[1] Note that the partial adjustment mechanism used here introduces one more lag than usual. This is to account for the time required for actual construction.

Demand for Structures

$$\log(K_i) = \alpha' + \beta' \log(LQ_i) + \gamma' \log \frac{LP_i}{V_i} + \delta' \log(LX_i) + \eta \log(LK_i) \tag{3}$$

where

$\alpha' = \alpha\lambda$
$\beta' = \beta\lambda$
$\gamma' = \gamma\lambda$
$\delta' = \delta\lambda$
$\eta = 1-\lambda$
L has the effect of lagging the variable one period.

The demand for new construction is derived using the stock demand (equation (3)) and the identity shown in equation (4):

$$K_i = LK_i + C_i - \theta LK_i \tag{4}$$

The identity states that the capital stock at the end of the period (K_i) is equal to the stock carried over from the previous period (LK_i), plus new construction during the current period (C_i), less the depreciation of the old capital stock. Depreciation is assumed to be a constant (θ) multiplied by the previous stock.

One of the variables determining the demand for structures, the user cost of construction, requires further explanation. The user cost is the portion of an asset's cost which can be attributed to use during the current year, that is, interest expense and depreciation. User cost, therefore, is

$$U_i = V_i(r+\theta) \tag{5}$$

where

r = interest rate
θ = the rate of depreciation
V_i = current purchase price of the asset

This formula, used in this study, does not account for capital gains on the asset or the effect of depreciation on income tax.

Disaggregation of Demand

Separate demand equations are estimated for four different types of private structures:

- industrial
- commercial
- utilities
- residential

The total private demand for structures is the sum of these demands. For residential structures, which are not used in production, some modification of the basic model is required. We use an equation similar in form to that used for industrial structures, except that the price of output is replaced by the consumer price index for all commodities except shelter (an index of the price of substitutes) and the output of the production process is replaced by real disposable income.

Measurement of Variables

To estimate the demand equation shown in equation (3), data are required on the stock of structures of individual types, the user cost of structures, the price of output for which the structure is an input, the quantity of output and the exogenous variables. Our estimates make use of annual, national data from 1948 to 1975.

The Stock of Structures

The stock of structures, of each type, is a created variable built up from new construction and a stock of structures in 1946. The stock of structures in the next year, 1947, is built by adding new construction and subtracting depreciation on the first year stock. Stocks for subsequent years are built the same way. For each year, stock is measured at the end of the calendar year.

The capital stock measures are based on the physical quantity of new construction. The quantity is measured as the value of new construction put in place measured in 1972 dollars; i.e., the value in current dollars divided by the GNP deflator for that type of construction, base 1972.

Clearly, the units of this quantity measure are not square feet or some other physical unit. Instead, the units are 1972 dollars, the current base of the GNP deflators. Nevertheless, this is a bona-fide quantity measure, since it is expenditure (PQ) divided by a measure of price (P).

Measures of the capital stocks were constructed for each of the types of construction discussed in this paper. Table 1 describes the sources of data on the initial capital stocks and the rate of depreciation.

In addition to the data listed in the table, the calculation of the capital stock requires new construction in 1972 dollars for specific categories of structure. These figures are from Construction Review.[1]

Data for 1972 to 1976 are from the June-July 1977 issue. For 1947 to 1971, data are from the December 1976 issue. The latter figures, quoted in 1967 dollars, were converted to 1972 dollars.

The Price of Structures

To measure the price (or replacement cost) of new structures, the GNP deflator for that type of structure was used. This deflator is the ratio of new construction put in place, in current dollars, to new construction put in place in constant dollars, as reported in the GNP accounts under purchases of structures by type, or in Construction Review and in other Department of Commerce publications. Forming the deflator in this way simply recovers whatever price index was originally used to deflate current to constant dollars. The individual deflators have been criticized on grounds that they were little more than a weighted average of materials prices and wage rates and did not capture gains in productivity or represent

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[1] U.S. Department of Commerce, Domestic and International Business Administration and Bureau of Domestic Commerce, Construction Review, December 1976 (Vol. 22, No. 10), pp. 7-10. Construction Review, June-July 1977, pp. 21-25.

TABLE 1

SOURCES OF DATA FOR INITIAL 1946 STOCK OF STRUCTURES AND DEPRECIATION RATES

Type of Structure	Source of initial stock	Adjustments on initial capital stock to make comparable to our categories	Depreciation rate
Private residential: includes farm housing	[1], p. 26, table 2. The reference measures the stock in 1946 dollars. This stock was adjusted to 1972 dollars using the GNP deflator for residential construction [2], p. 294. In 1946 the deflator, base 1972, takes value .44.	Since our category includes only structures and only private investment, we subtracted from the estimates in [1] the stock of mobile homes and the stock of public housing.	[1], page 33, lists depreciation as 2 percent for structures of 1 to 4 units, 2.4 percent for more than 4 units and 3.5 for nonhousekeeping structures such as hotels. To form a single rate of depreciation, these were weighted together by their shares in the 1961 capital stock [1]; that stock is expressed in 1958 dollars. The resulting rate is 2.05 percent.
Industrial	[3], p. 93. This is quoted in 1958 dollars. We adjusted it to 1946 dollars, using the implicit deflator of [3], formed by dividing investment in industrial structures as quoted in [3], p. 433, by investment in constant dollars [3], p. 457. The stock in 1946 dollars was then adjusted to 1972 dollars using the GNP deflator for industrial structures [2], p. 294.	Our investment series does not include purchases of used structures from the federal government; these are included in the stock in [3], but no adjustment was possible.	The rate of depreciation was estimated as the ratio of the sum of depreciation, 1968-1972 over the sum of the capital stocks at the end of the previous years. The resulting estimate is 8.68 percent annually, calculated from data on page 93 of [3].

TABLE 1 - continued

Type of Structure	Source of initial stock	Adjustments on initial capital stock to make comparable to our categories	Depreciation rate
Public Utilities: includes gas, electric light and power, railroad and petroleum pipelines	Our category, utilities, comprises three categories from [3]: railroad and pipeline, telephone and telegraph, and other public utilities. The last includes gas and electric light and power. For these three categories, the 1946 stocks are from [3], pages 97, 98, and 99, respectively. Converting to 1946 dollars uses a deflator formed by dividing current investment by deflated investment. Data on current investment on pages 433 and 436 of [3] and data on real investment on pages 457 and 460 of [3]. Converting from 1946 to 1972 dollars uses the revised GNP deflator [2], p. 294 from [2], p. 294.	Same as industrial structures.	Depreciation rates estimated for each of the three categories of utilities [3], for 1968 to 1972 in the same fashion as industrial structures. These depreciation rates used data on depreciation and net stocks on page 97 of [3] (railroad and pipeline), page 98 [3] for telephone and telegraph, and page 99 [3] for gas and electric light and power. The estimated rates are .065 for railroad and pipelines, .125 for telephone and telegraph and .083 for gas and electric light and power. The three depreciation rates were combined into one rate using weights proportional to the capital stock from [3] in 1961. The stocks are presented on pages 97 (railroad and pipelines), 98 (telephone and telegraph) and 99 (gas and electric light and power).

TABLE 1 - continued

Type of Structure	Source of initial stock	Adjustments on initial capital stock to make comparable to our categories	Depreciation rate
Commercial	[3], p. 94. Quoted in 1958 dollars. Adjustment to 1972 dollars same as for industrial, using implicit deflator from current and deflated commercial construction, page 433 and page 457 of [3], and GNP deflator for industrial structures [2], p. 294.	Same as above. Also capital stock in [3] includes miscellaneous as well as commercial. To make comparable with our data on investment in commercial structures, we multiplied by the ratio of commercial construction [4] to investment in commercial and misc. structures [3], p. 433.	Same as above using data from page 94 of [3]. Rate of depreciation estimated at 6.6 percent.

[1] John C. Musgrave, "New Estimates of Residential Capital in the United States, 1925-1973," Survey of Current Business, October 1974 (Vol. 54, No. 10), pp. 32-38.

[2] U.S. Department of Commerce, Bureau of Economic Analysis, The National Income and Product Accounts of the United States, 1929-1974, GPO 1976.

[3] U.S. Department of Commerce, Bureau of Economic Analysis, Fixed Nonresidential Capital in the United States, 1925-1973, National Technical Information Service, Springfield, Va., January 1974.

[4] U.S. Department of Commerce, Domestic and International Business Administration and Bureau of Domestic Commerce, Construction Review, December 1976 (Vol. 22, No. 10), page 7.

the actual prices paid for new structures. The data used in this study should not be subject to that complaint. A major revision of the construction deflators back to 1947 was completed by the Commerce Department in 1974. The sources of the revised indices are presented in table 2.

Estimated Demand for Structures

The demand for structures was estimated using annual time series data from 1948 to 1975. An exception was the demand for residential structures, estimated from 1949 to 1975, the span of the data on the appropriate interest rate. Results are shown in table 3.

Estimates of these and subsequent equations are made using ordinary least squares corrected for first order serial correlation. Simultaneous equation methods, such as two stage least squares, were not used because the number of exogenous variables exceeds the number of observations, making impossible standard estimation techniques such as two-stage least squares. This is a standard problem with multiple equation models. There are several possible solutions. One is to select a group of exogenous variables and use only these for the first stage of two-stage estimation. Another is to use for exogenous variables an arbitrary number of the principal components of the exogenous variables. Both strategies are, to some extent, arbitrary, since the number of exogenous variables or principal components selected is arbitrary. As the number of exogenous variables selected approaches the number of observations, both two-stage techniques get closer and closer to ordinary least squares. Principal components have an added arbitrary element; they are sensitive to units of measurement.

Aside from the arbitrariness of the two-stage methods, the choice of ordinary least squares was motivated by several considerations. First is its simplicity. Second, though the two-stage techniques are consistent and ordinary least squares is not, consistency refers to very large samples, whereas our model, like most multiequation models, is at the opposite extreme; the number of degrees of freedom is not only small, but if the full two-stage techniques were attempted, negative. Third, though ordinary least squares is biased, even in large samples, its variance is low, so the mean square error is not necessarily greater.

TABLE 2

INDEXES USED TO FORM THE NEW GNP DEFLATOR FOR CONSTRUCTION

Type of Construction	Indexes
Residential buildings, farm and nonfarm	1947-1963 unweighted average of 70 cities. Index[a] and Federal Housing Authority price per square foot
Industrial buildings Commercial buildings Farm - nonresidential Educational Hospital Institutional Religious	Unweighted average of Turner Construction Co. Residential index and Bureau of Public Roads index of the cost of building structures
Railroads	Interstate Commerce Commission - Railroad Construction Price Index
Telephone and telegraph	Weighted average of: Bell System indexes for building and outside plant
Electric light and power (private)	Handy-Whitman Electric plant and Utility buildings
Gas plant and pipelines	Interstate Commerce Commission index of the cost of pipelines
Petroleum pipelines	Interstate Commerce Commission index of the cost of pipelines
Military Facilities	Weighted average of Bureau of Public Roads Composite and residential index above

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[a] The 70 Cities Index was prepared by the Department of Commerce from administrative records of the Federal Housing Administration.

Table 2 - continued

Type of Construction	Indexes
Highways and streets	Bureau of Public Roads composite
Sewer systems	Environmental Protection Agency sewers and sewage treatment plant
Water supply facilities	Weighted average of: sewer systems (above) and Interstate Commerce Commission index of the cost of pipelines
Conservation and development	Bureau of Reclamation composite
Other	Unweighted average of: Bureau of Public Roads composite and Bureau of Reclamation composite

Source: "Revised Deflators for New Construction, 1947-1973," Survey of Current Business, August 1974, pp. 18-26.

TABLE 3

ESTIMATED DEMAND EQUATIONS
(coefficients, with t values
in parentheses)

Right-hand side variables	Dependent Variable (1) log (stock of residential structures)	(2) log (stock of commercial structures)	(3) log (stock of industrial structures)	(4) log (stock of structures owned by public utilities)
intercept	.87 (2.3)	-.20 (-.92)	.67 (1.5)	1.3 (2.0)
log (output of demanding sector, lagged once)	.14 (2.8)	.31 (2.7)	.26 (4.2)	.05 (1.7)
log (relative user cost, lagged once)[a]	-.04 (-2.2)	.-12 (-2.5)	-.08 (-2.2)	
log (dependent variable, lagged once)	.86 (17.0)	.89 (12.2)	.74 (12.0)	.87 (12.5)
log (capacity utilization)			.19 (3.3)	
log (relative user cost, not lagged)		-.06 (-1.2)		
R^2	.99	.99	.99	.99
D.W.	1.79	1.25	1.38	1.32
$\hat{\rho}$	.52	.79	.70	.92

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[a] Relative user cost is user cost divided by price of output

In regression equations (1) and (2), output of the demanding sector is measured by disposable income, measured in 1972 dollars. In regression equation (3), output of the demanding industry is measured by the Federal Reserve Board (FRB) index of industrial production. Capacity utilization is measured by the FRB index. The coefficient on output was constrained to equal one minus the coefficient on the lagged dependent variable. This constraint has the effect that, in the long run, the demand for structures is proportional to output.

THE SUPPLY OF STRUCTURES: PRIVATE

The supply of new structures takes, as given, the prices of purchased inputs. Thus, the slope of this supply curve does not take account of changes induced in the prices of purchased factors by changes in the output of new structures. These induced changes are considered elsewhere in the model.

In graphical presentations, supply schedules are usually drawn with quantity supplied as a function of price. In empirical studies of industry, however, price is typically used as the variable to be explained. Since price and quantity are both determined within the same market, there is no theoretical reason to prefer one formulation to the other.

For several reasons, it is convenient to use price as the dependent variable. First, this form allows for the possibility that the supply is completely elastic, a finding more common in empirical work than that supply is completely inelastic. Also, it allows direct representation of sluggishness in the price by including the previous period's price as an explanatory variable. Consequently, we follow the convention generally used in empirical work.

With price as the dependent variable, quantity enters as one of the right-hand variables. Quantity is introduced in the form of capacity utilization, quantity divided by capacity.

Even if quantity turns out not to enter the supply curve, i.e., the supply curve is completely elastic, the model still describes how price and quantity are determined. In this case, the horizontal supply curve determines the price. Given this price, the demand curve determines quantity.

The Price of Purchased Inputs

For each type of structure, an overall index of input prices is formed by combining the prices of individual inputs into a fixed weight or Laspeyres index. As is well known, the Laspeyres index does not account for substitution against high priced inputs and, hence, overstates increases in the price of a composite bundle of inputs. For example, the index does not account for the substitution of materials and capital for labor if the price of labor rises more rapidly than the prices of the other factors of production.

To form the indices for different structures, the prices of individual inputs in each year are weighted by the share of those inputs in total cost in the base year (see table 4). Four factors of production are distinguished: labor, materials, rental equipment, and contractor's overhead. The weights are available from surveys by the Bureau of Labor Statistics. Because the surveys are conducted in different years for different types of construction, we base each index in the year of the survey. When surveys were not available for a particular type of construction, weights for a similar type of construction were used.

The prices of each factor are drawn from standard published sources. The price of materials is the wholesale price index for construction materials and components.[1]

The price of labor is average hourly earnings of production workers in contract construction, reported in Employment and Earnings.[2]

This series is adjusted to include fringe benefits using information on total compensation and on wages

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[1] This is part of Wholesale Price Index by Stage of Processing. Data from 1947-1974 are available in U.S., Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, Reference Edition, 1975 (BLS Bulletin 1865), page 354.

[2] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, United States, 1909-75 (Bulletin B12-10), 1976, p. 26. This source provides annual data through 1974. More recent data were obtained from the Department of Labor periodical, Employment and Earnings.

TABLE 4

DISTRIBUTION OF CONTRACT COSTS

Type of Construction	Year	On-site Wages	Materials	Construction Equipment	Overhead and Profit
Residential[a]	1969	.204	.434	.009	.353
Industrial[b]	1959	.290	.514	.019	.177
Commercial[b]	1959	.290	.514	.019	.177
Utilities[b]	1959	.290	.514	.019	.177

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[a] Source: U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 1892, "Labor and Material Requirements for Private Multifamily Housing Construction," GPO, Washington, D.C. 1976. This bulletin contains on pages 23 and 24 a summary of earlier construction surveys by BLS.

[b] Source: Same as a. Surveys had not been performed for industrial, commercial, or utilities. We therefore used the factor proportions for federal office buildings.

and salaries from the GNP accounts.[1] Since total compensation reported in the GNP accounts does not distinguish between production workers and others, our adjustment assumes that fringe benefits as a fraction of salary is the same for production and nonproduction workers.

The price of equipment is measured as the user cost, i.e., the purchase price multiplied by the interest rate plus the rate of depreciation. The measure of the initial price is the wholesale price index for construction machinery and equipment.[2]

The interest rate is the bank rate on short term business loans.[3] The depreciation rate, 32 percent, is calculated from Department of Commerce estimates of the stock of construction machinery and the total depreciation of this stock.[4]

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[1] U.S. Department of Commerce, Bureau of Economic Analysis, The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables (GPO Stock Number 003-010-0052-9), 1976. Compensation to employees is on pages 194 to 197. Wages and salaries or compensation less fringe benefits is on pages 198 to 201. These series run through 1974, but 1973 and 1974 are provisional. More recent and revised series are available in U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1977 (Vol. 57, no. 7), page 46, tables 6.5 and 6.6.

[2] U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, 1975, Reference Edition (Bulletin 1865), 1975, page 350. This source provides data through 1974. More recent data are available in the Bureau of Labor Statistics publication, Wholesale Prices and Price Indices.

[3] Economic Report of the President, 1977, U.S. Government Printing Office, Washington, D.C., 1977, page 260. The name of the data series is "average rate on short term bank loans to business--selected cities."

[4] U.S. Department of Commerce, Bureau of Economic Analysis, Fixed Nonresidential Business Capital in the United States, 1925-1973, National Technical Information Service, Springfield, Virginia, 1974, page 271. To estimate percentage depreciation, we divided the sum of depreciaton, 1968-1972, by the sum of the net capital stocks at the end of the previous years.

From the weights and price indexes described above, an index (C) of input prices was formed. This index included materials, labor, and equipment but not overhead. As our measure of overhead expense, we use the rate of interest on short term business loans. Overhead costs were incorporated by multiplying the index of input prices (C) by one plus the interest rate, and converting the resulting product to an index. This procedure implicitly assumes that construction loans are, on the average, one year long.

The Supply Price of New Structures

The determinants of price are estimated using annual data, 1948 to 1975. The least squares estimates are corrected for first order serial correlation. Estimates are shown in table 5 with t-values in parentheses.

PUBLIC CONSTRUCTION: SEWER SYTEMS

Because the major focus of this study is the construction generated by pollution control, sewer systems are studied much more intensively than other forms of state and local construction. To do this, we divide state and local construction into two categories: sewer systems and all others, even though, in 1972 sewer systems made up only 7 percent of the value put in place for state and local construction.

The sewer systems category comprises sewer lines and sewage treatment plants. Sewer lines are the underground channels which carry sewage from a home or building to a treatment plant or body of water. Collector lines, which first receive the sewage, empty into the larger interceptor lines which carry the sewage to the treatment plant if there is one.

Sewage treatment plants process the sewage which is water with a small fraction of organic or industrial contaminants. The degree of processing is classified by the extent to which it reduces the concentration of the contaminants. The first stage of treatment, called primary processing, involves running the sewage through a large tank where the contaminants drop out. Sometimes chemicals are added to aid the precipitation.

When the sewage has been through primary treatment, the liquid portion, partly purified, may enter secondary treatment. One of many forms of secondary treatment is the trickling filter, a bed of stones surrounded by

TABLE 5

ESTIMATED EQUATIONS FOR SUPPLY PRICE

	Dependent Variables		
Explanatory Variables	(1) Log (GNP deflator for residential structures)	(2) Log (GNP deflator for commercial and industrial structures)	(3) Log (GNP deflator structures built for public utilities)
Intercept	.049 (.72)	-.33 (-4.1)	-.25 (-4.4)
Log (input prices)	.66 (7.3)	.94 (9.4)	.69 (6.9)
Lagged dependent variable	.31 (3.0)	.06 (.65)	.36 (3.5)
Time	-.0056 (-1.81)	-.0050 (-1.5)	-- --
R^2	.96	.88	.94
$\hat{\rho}$	.86	.91	.88

The GNP deflators for commercial buildings and industrial buildings are the same, so the equations are combined in (2). The coefficient on the lagged dependent variable is constrained to be one minus the coefficient on input prices. This constraint imposes complete shifting of price increases.

concrete walls. The stones have been coated with a bacterial slime which consumes the organic components of the sewage as the sewage is sprayed over the stones.

Secondary treatment is sometimes followed by more advanced treatment. From each stage, the contaminants removed emerge as sludge to be disposed of.

Sewer System Construction Since 1947

After World War II, there was a backlog of sewer projects; sewer construction rose steadily. By 1951, construction matched peak levels attained before the war.[1]

Federal grants-in-aid began in the 1950s but did not become a major factor in meeting construction costs until 1966. The $50 million authorized in 1957 was about 6 percent of 1957 expenditures on sewer system construction.[2]

Major grants-in-aid began in 1966, with the Clean Water Restoration Act. This act authorized grants rising to $1.25 billion in 1971, an amount which would have equalled 68 percent of 1971 sewer system construction. In fact, .478 billion was spent, 26 percent of expenditures on sewer systems.

In 1972, the Federal Water Pollution Control Act authorized $18 billion to be obligated over three fiscal years, 1973 to 1975. Clearly, these were subsidies of unprecedented size. Indeed, this is one of the largest public works program ever undertaken. In 1973, if it had been feasible to spend the $5 billion earmarked for that year, federal grants would have been larger than any year's grant for the interstate highway system.

Though authorizations of the $18 billion started in fiscal year 1973 with $5 billion, only $.75 billion was actually spent. Expenditures rose to $1.6 billion in 1974, $2 billion in 1975, and $2.5 billion in 1976.

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[1] Milford A. Edwards, Requirements for State and Local Public Works Construction, Construction Review, May 1955, Department of Commerce, p. 4.

[2] U.S. Environmental Protection Agency, Economic Report: Alternative Methods of Financing Wastewater Treatment, Report to Congress, October 1975, appendix A, p. A-2.

It was widely recognized that when the money authorized under the 1972 Act was gone, more would be authorized. The extra funding, $24.5 billion, was provided by the Clean Water Act of December 1977: $4.5 billion for fiscal 1978 and $5 billion annually for fiscal years 1979 through 1982. Though the Senate and the Carter Administration wished to reserve funds for treatment plants, the final version of the bill required that 25 percent or more be spent on sewer lines.

It seems likely that the grants-in-aid have several purposes: (1) to provide income for municipalities, (2) to encourage construction of sewer systems, and (3) to provide construction employment. Realization of the first purpose seems certain, but realization of the other two is less certain. Municipalities may reduce other expenditures on sewer systems, letting the Federal Government pay for projects that would have been undertaken anyhow. Moreover, even if grants-in-aid lead to long run increases in expenditure, there is likely to be a period when the funds are authorized but not spent because municipalities temporarily curtail their spending plans, hoping to qualify for federal matching grants. To the extent that construction does not increase as a result of the grants, employment will not change.

Let us consider the long run effect on output first. It seems clear that if federal grants are for exactly those projects the community would have undertaken anyhow, there will be little encouragement of the subsidized activity. The municipality will simply add the funds into its total budget to be spread across all local government activities or cut taxes. The subsidized activity will increase no more than other activities. The community will reduce its own financing of the subsidized activity by almost as much as the subsidy.

To the extent that displacement is less than complete, the subsidy must be encouraging an activity that the community would not fund on its own. For sewer systems, it has been suggested that sewage treatment plants are more likely to be different from the communities' plans than sewer lines, so that displacement is less likely.

In addition to the long run effect of grants on sewer expenditures by the municipalities, we also hypothesize a short run effect. When federal funds are first authorized, communities may delay spending they had already planned to finance on their own, hoping for federal grants. Indeed, after the 1966 and 1972 grant programs passed Congress, the major authorizations of funds covered by our data, there was an immediate sharp drop in sewer expenditure. As early as 1966, it was recognized testimony that municipalities were holding up construction plans, hoping for federal subsidies.

> "The slowness in receiving Federal grants was repeatedly mentioned as a deterrent, both because municipalities delayed construction in hopes of eventually receiving Federal dollars, and because even approved projects could experience lag times of several years."[1]

Even after major federal grants began in 1966, fluctuations in sewer expenditures were extreme. If community plans have been delayed pending federal grants, there will be a dual effect when the federal funds are spent. Not only will the subsidized activity be encouraged by the federal subsidy, but the expenditure will coincide with an unblocking of delayed local funds. When major expenditures under the 1972 Act began in 1975 Act began in 1975 and 1976, constant dollar sewer system expenditure rose to more than 50 percent above any preceding year.

The Demand for Sewer System Structures

Our statistical work on the determinants of state and local expenditures on sewer systems draws on earlier work by Gramlich and Galper. Their papers are not specific to sewer system expenditure; rather, they describe state and local expenditures as a whole and, separately, state and local construction expenditure. In a 1973 paper, Gramlich and Galper[2] present estimates of demand for state and local construction based on quarterly time series data, 1954 to 1972. The variable to be explained is per capita discretionary expenditures on construction in constant dollars.

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[1] U.S. Environmental Protection Agency, Economics Report: Alternative Methods of Financing Wastewater Treatment, October, 1975, Appendix A, p. A-6.

[2] Edward M. Gramlich and Harvey Galper, "State and Local Fiscal Behavior and Federal Grant Policy," in Brookings Papers on Economic Activity (1:1973), pp. 15-65.

Discretionary expenditures are total expenditures less federal subsidies and less state and local expenditures to match the federal subsidies. Important determinants of this variable are constant dollar per capita income, the user cost of new construction, the existing stock of state and local structures, and the fraction of the population that is of school age.

In the estimated equation, current federal expenditures seem not to reduce discretionary expenditures but instead are added on to what the localities would have spent anyway. This leads to an inconsistency, for past federal expenditures are included in their measure of the state and local capital stock; as part of this stock, federal expenditures do displace state and local expenditures.

In a more recent paper,[1] Gramlich updates his results and considers how accurate have been projections formed from his model. He reports that his estimates of construction expenditures are too high and conjectures that waiting for federal funds may provide an explanation.

Our estimates of the demand for sewer system expenditure draw on both the Gramlich-Galper work and our own model of private construction described earlier. We both start with the presumption that demand is for a stock of structures. Gramlich and Galper restate this demand to describe new construction. We use the stock of structures directly.

Measurement of Variables

The stock of structures is divided into two parts, a discretionary stock built with the communities' own funds, K_d, and one built with past and present federal grants, K_g. As opposed to Gramlich and Galper, we treat state and local expenditures for matching federal grants as discretionary. To derive the demand for structures, we define an effective capital stock which includes the discretionary stock plus some fraction (γ) of the grant. We weight the contribution of a grant at less than its full cost. Since the community would not have made the investment on its own, the community must value it less than it would value discretionary expenditures. K is thus defined by:

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[1] Edward M. Gramlich, "State and Local Budgets the Day After it Rained: Why is the Surplus so High?" Brookings Panel Sector Report, 1978, preliminary draft.

$$K = K_d + \gamma K_g \ . \qquad (6)$$

The parameter γ determines the extent to which federal grants displace other state and local expenditures. If γ is 1, then federal grants substitute completely for state and local expenditures; displacement is complete.

To derive an equation to be estimated, we assume that the effective capital stock is a log-linear function of the stock of residential structurs R. (We also tried the user cost for sewer systems relative to the deflator for disposable income, but this showed little effect.) To represent lagged adjustment, we also enter the lagged effective stock (LK).

$$\ln K = \ln \alpha + \beta \ln R + \eta \ln LK \qquad (7)$$

Since K can not be observed, it is convenient to rewrite 6, substituting $(K_d + \gamma K_g)$ for K and eliminating the logarithms. We also add a variable K_u, the stock of grants authorized but not yet spent. Its purpose is to represent postponement of discretionary expenditure in hopes of obtaining federal grants. The resulting equation to be estimated is:

$$K_d = \alpha R^{\beta}(LK_d + \gamma LK_g)^{\eta} - \gamma K_g + \delta K_u \qquad (8)$$

Note that K_U has been added linearly, not log linearly. The reason is that the log linear form would imply that a doubling of authorizations has the same percentage effect when authorizations are very small as when they are very large.

The Stock of Sewer System Structures

To estimate this equation requires data on several stocks of capital, the discretionary stock and the stock of grants. These are measured with the same perpetual inventory method described earlier. Starting with an initial year stock for 1946, the stock for succeeding years is estimated by adding new sewer system construction (in 1972 dollars) and substracting depreciation. Depreciation is assumed to be a constant proportion of the preceding year's stock. The calculations are described in table 6.

TABLE 6

SOURCES OF DATA FOR 1946 STOCK OF SEWER SYSTEM STRUCTURES AND RATES OF DEPRECIATION

Type of Structure	Source of initial stock (1946)	Sources for gross additions to capital stock after 1946	Source of depreciation rate
Sewer systems: sewer lines treatment plants	Calculated by summing constant-dollar investment from 1850 to 1946, each year subtracting 4 percent depreciation. The 4 percent results from an assumption that all sewer systems constructed before 1946 were sewer lines not treatment plants. Sewer systems first appeared in the U.S. about 1850 [1]. From 1850 to 1914 sewer system construction was assumed to grow linearly. From 1915 to 1946, value put in place in 1957-1959 dollars was from [2]. The capital stock in 1957-1959 dollars was then adjusted to 1972 dollars.	New construction in sewer systems 1947-1971 from [3]. These were converted from 1967 dollars to 1972 dollars. New construction in sewer systems 1972-1975 in 1972 dollars from [4]. The split of recent sewer construction between plants and sewer lines used data in [5].	Depreciation rates were obtained from economic lifetimes provided by R. L. Michel of EPA: 50 year for sewers and 20 years for treatment plants. We used the double declining balance method of depreciation for sewers, i.e., the linear rate, .02, was doubled to .04 and applied to the net stock available at the end of the previous year. Similarly, treatment plants were depreciated at .10 annually.
Sewer systems built with grants	Zero until 1956, when grant expenditures began.	Grants-in-aid from 1957 to 1962 [6]. From 1963 to 1975 [7]. For 1976 [8]. These are in current dollars and are for the fiscal year ending June 30. The data were deflated using the implicit price deflator for sewer systems, then averaged to approximate calendar year expenditures. For example, estimated expenditures in calendar 1972 is the average of expenditure for fiscal year 1973, each deflated before averaging.	

TABLE 6 - continued

1. Columbia Encyclopedia, Second Edition, "Sewage."
2. U.S. Department of Commerce, Bureau of the Census, Value of New Construction Put in Place 1947 to 1974 (Construction Reports, series C30-74S), U.S. Government Printing Office, Washington, D.C., 1975, p. 185.
3. U.S. Department of Commerce, Domestic and International Business Administration and Bureau of Domestic Commerce, Construction Review, December 1976 (Volume 22, No. 10), p. 12.
4. U.S. Department of Commerce, Bureau of Census, Value of New Construction Put in Place (Construction Reports C30), May 1977, pp. 30-34.
5. The Council on Environmental Quality and the Environmental Protection Agency.
6. U.S. Executive Office of the President, Environmental Quality: Seventh Annual Report of the Council on Environmental Quality, 1976, GPO, p. 17.
7. U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, Annual Data for 1961 and 1962, 1967 issue p. 420; Data for 1963 to 1970, 1971 issue, p. 417; Data for 1972 to 1975, 1976 issue, p. 262.
8. U.S. Executive Office of the President, Office of Management and Budget, Budget of the United States Government: Special Analyses, Fiscal Year 1978, p. 313.

Other Variables

The stock of residential structures was described earlier. The stock of unspent authorizations is formed by cumulating all past authorizations and subtracting expenditures. Authorizations are entered in the year the authorizing legislation is passed. Basic data on authorizations and expenditures are from the annual report of the Council on Environmental Quality, 1976.[1]

Estimated Demand for Sewer System Structures

The demand for sewer system structures was estimated using annual data for 1948 to 1975. The nonlinear least squares estimates are presented in table 7.

One might expect substantial collinearity between the various stocks on the right-hand side of equation (8). For instance, the current stock of grants appears along with the same stock lagged once. Nevertheless, a sufficiently strong relation between the right-hand variables and the dependent variables will allow precise estimates of coefficients even in the presence of collinearity. This seems to be the case here; the t-values indicate that all coefficients are significant at the 5 percent level.

Long run demand is about proportionate to the stock of structures. The estimate of .52 for γ indicates that, in the long run, about one-half of federal grants displace state and local expenditures. Each dollar of new grants authorized temporarily depresses state and local expenditure by four cents due to waiting upon federal grants. If grants of $5 billion are authorized for each of five years, the temporary displacement is $1 billion or 20 percent of the annual appropriation.

The Supply of Sewer System Structures

As was done in analyzing the various categories of private construction, we again follow the convention of using price as the dependent variable. The price of sewer system construction is expressed as a function of input prices and a lagged dependent variable. A time trend was dropped because of extreme lack of statistical significance.

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[1] U.S.Executive Office of the President, Environmental Quality: Seventh Annual Report of the Council on Environmental Quality, 1976, GPO, p. 17.

TABLE 7

ESTIMATED DEMAND FOR THE STOCK OF SEWER SYSTEM STRUCTURES

$$K_d = \alpha R^{\beta}(LK_d + \gamma LK_g)^{\eta} - \gamma K_g + \delta K_u \qquad (8)$$

Parameter	Estimated value	t-value
α	.55	2.6
β	.24	2.2
η	.74	6.7
γ	.52	2.3
δ	-.04	2.1

R^2 = .998
D.W. = 1.97

Variables

K_d, LK_d	Discretionary stock of structures and stock lagged once
K_g, LK_g	Stock of grants and stock lagged once
K_u	Stock of grants authorized but unspent
R	Stock of residential structures

Separate indices of input prices were estimated for sewer lines and sewer plants because they used different combinations of resources. Weights are listed in table 8.

TABLE 8

PERCENT DISTRIBUTION OF CONTRACT COST

Category	Sewer Lines	Sewer Plants
On-site wages	.243	.302
Materials	.352	.365
Construction Equipment	.167	.067
Overhead and Profit	.238	.266

SOURCE: Robert Ball and Joseph T. Finn, "Labor and Materials Requirements for Sewer Works Construction," Monthly Labor Review, November 1976, pp. 38-41. This article reports results of a survey taken in 1971. The shares for different factors are summarized in table 4, page 40. We have used the figures for sewer lines without adjustment. For treatment plants, an adjustment was made to eliminate pollution abatement equipment. Data for this adjustment was from R.L. Michel, "Different Methods of Calculating On-Site Direct Labor Man Years for Construction of Municipal Wastewater Treatment Facilities," Environmental Protection Agency, February 1977.

As with input prices for private construction, overhead and profit are represented by the interest rate on short term bank loans. An index of prices is constructed from on-site wages, materials, and construction equipment, using sources described in table 8. The resulting index is then multiplied by one plus the short term interest rate, and this product converted to an index.

To measure the price of sewer system construction, the variable to be explained, we use the GNP deflator for sewer system construction. This is the ratio of the sewer system value put in place, in current dollars, to the value put in place in 1972 dollars. Both are reported in Construction Review.

The equation describing the price of sewer system construction was estimated using annual data, 1948 to 1975. Least squares results, adjusted for first-order serial correlation, are shown in table 9.

TABLE 9

ESTIMATED EQUATION FOR PRICE OF SEWER SYSTEM CONSTRUCTION

Dependent variable:	log (price)	
	coefficient	t-value
intercept	-.036	-1.9
log (index of input prices)	.70	7.0
lagged dependent variable	.39	4.2

R^2 .99
D.W. 1.91
$\hat{\rho}$ .40

OTHER STATE AND LOCAL CONSTRUCTION

We now turn from the explanation of sewer system construction to the much larger category of other state and local construction. As illustrated in table 10, over 60 percent of state and local construction is for highways, streets, and educational buildings. Hence, the size of the school-age population and the availability of federal highway grants should be major determinants of the demand for structures.

TABLE 10

STATE AND LOCAL CONSTRUCTION BY TYPE

	State and local construction put in place 1972 (millions of dollars)	Percentage of total
Educational buildings	5,694	22
Other buildings	4,676	18
Highways and streets	10,130	39
Other nonbuilding	3,590	14
Sewer systems	1,702	7
Total	25,792	100%

SOURCE: U.S. Department of Commerce, Bureau of the Census, Value of New Construction Put in Place, May 1977 (C30-775), p. 38.

Determinants of Postwar Growth

The major determinants of postwar movements in state and local construction were unmet demands left over from the depression and the war, the growth and peaking of the school-age population, and the growth and peaking of the interstate highway program.

Even 10 years after the war, it was reported that state and local construction had failed to catch up with "requirements." In 1954, construction of schools and highways were claimed to be 60 percent and 40 percent below requirements, where the requirement for new constuction was the rate of new construction necessary to catch up with a target stock of structures by 1964.[1] The method for determining the target stock was not clear. At least in part, it was defined by asking localities about their "needs" and hence, the estimates were probably overstated.

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[1] Milford A. Edwards, "Requirements for State and Local Public Works Construction," Construction Review, May 1955, pp. 4-9.

Though the requirements may have been overstated, school construction did increase dramaticaly. Even after adjusting for inflation, the outlays during the first five years of the 1950s were as great as during the preceding 15 years. The large outlays were attributed to the "rapidly growing school population, obsolescence, deferred construction, and substantial shift in population."[1]

In 1961, the school-age population as a fraction of population began to fall, although it continued to grow in absolute numbers. In absolute numbers, the school-age population peaked in 1966 at almost 50 percent above its 1950 level. From 1967 to 1975, school construction fell by over 33 percent.

Expenditures on highways and streets followed a similar pattern. As shown in figure 2, constant dollar construction almost tripled from 1950 to 1968, then fell by more than 40 percent by 1975. A ready explanation is the growth and decline in federal grants-in-aid, especially funds for the interstate sytem.

Before 1956 and the large federal subsidies, toll roads were becoming increasingly important, rising from less than 2 percent of new highway construction to over 14 percent in 1954. But toll roads were not eligible for the sharply increased aid, and after 1956, toll road construction diminished.[2,3]

The increased aid became available with the Federal Aid to Highways Act and the Highway Revenue Act, both of 1956. These acts not only established the interstate system with 90 percent federal participation but also increased federal aid to other state and local roads. The increased grants-in-aid coincided with sharply increased highway spending. Subsidies and highway construction peaked, then fell in the late 1960s. That the pattern of road building paralleled the pattern of grants provides support for the hypothesis that, for

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[1] "Review of Construction in 1958," Construction Review, p. 9.

[2] "Review of Construction in 1957," Construction Review, U.S. Department of Commerce, February 1958, p. 7.

[3] See footnote 2.

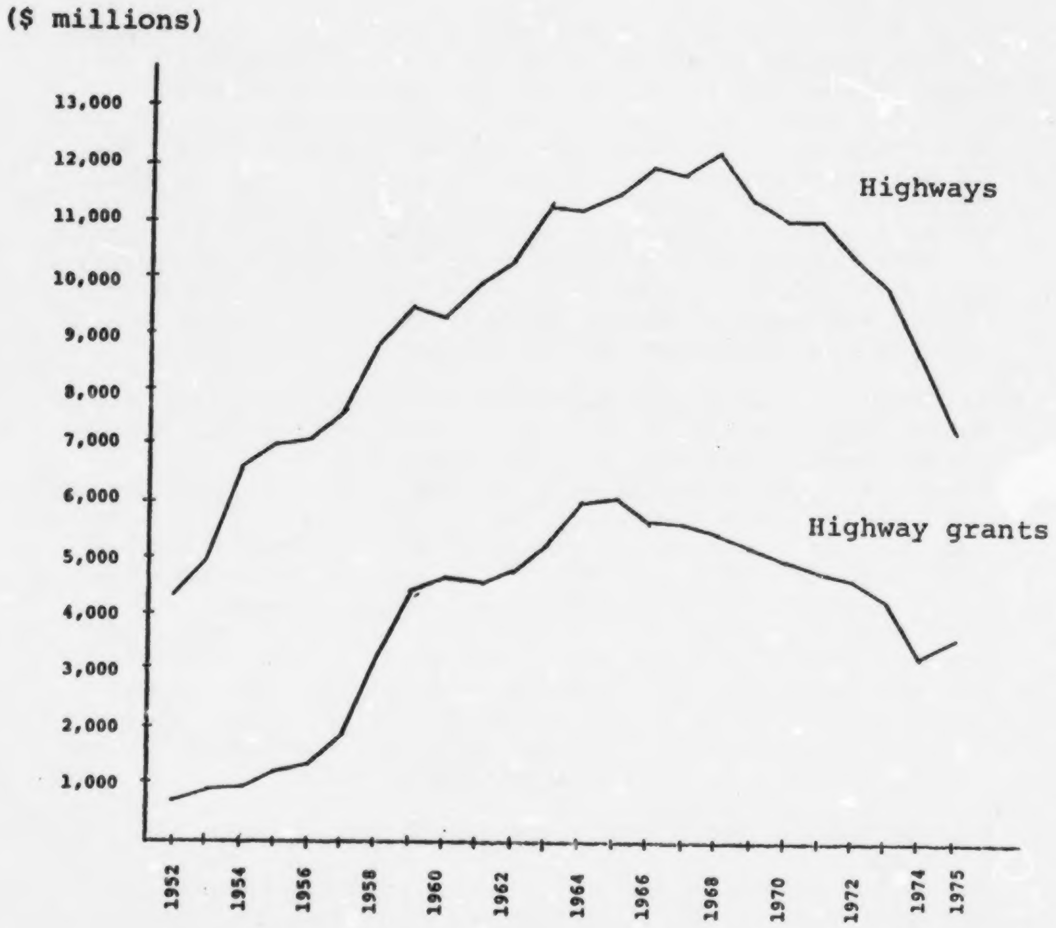

FIG. 2: Highway Grants and Expenditures on Highways, 1952-1975

road building, federal grants increase the amount of construction expenditure rather than simply shifting the financing.

The Demand for Other State and Local Structures

The discussion above suggests that the school-age population and the level of federal grants be included as determinants of demand for state and local structures. As the dependent variable we used structures built with local funds and included, as independent variables, both the stock of capital built with grants- in-aid and the stock of authorizations not yet spent. The latter we measured as the sum of school expenditures in the following three years. Both the stock of grants and unspent authorizations showed little statistical significance and so were dropped from the model. The interpretation is that grants do not displace the municipalities' own expenditures; therefore, construction expenditures are increased by the amount of the grants.

As shown in table 11, the full set of explanatory variables included the user cost of state and local structures (less sewer system construction), total population, per capita disposable income, and the fraction of the population of school age. Data sources for these and for the stock of structures, the dependent variable, are described in tables 12 and 13. The stock of structures was constructed using the perpetual inventory method, starting with an initial year stock and, for each year, adding new construction in constant dollars and subtracting depreciation. Table 12, listing the data used to create the stock of structures, shows sources of data for the initial stock, additions to the stock, and the rate of depreciation.

The Supply of Other State and Local Structures

The price of state and local structures, measured by the appropriate GNP deflator, is expressed as a function of an index of prices for factors of production and of the lagged dependent variable.

The index of prices for factors of production is a Laspeyres index of wages, materials, and equipment. The entire index is multiplied by 1+r where r is the short term interest rate on bank loans. The resulting product is then converted to base 1973, the year of one of the surveys from which the weights are drawn.

Because state and local construction includes both building and nonbuilding construction, we formed a

TABLE 11

ESTIMATED DEMAND FOR STOCK OF OTHER STATE AND LOCAL STRUCTURES

$$\log(K) = \alpha + \beta \log(LV/LP_D) + \gamma \log(LD)/LPOP) + \delta \log(POP) + \eta \log(SPOP) + (1-\lambda) \log(LK) \qquad (10)$$

Parameters	Estimated value	t value
α	.73	5.0
β	-.05	-5.3
γ	.12	4.2
δ	.12	4.2
η	.12	4.1
$1-\lambda$	.88	30.

R^2 = .998
D.W. = 1.67
$\hat{\rho}$ = .47

Variables

K,LK	Stock of other (i.e., other than sewers) state and local structures and stock lagged once
LV	User cost lagged once
LP_D	Implicit price deflator for disposable income, lagged once
LD	Disposable income, lagged once
POP, LPOP	Population and lagged population
SPOP	School-age population

TABLE 12

SOURCES OF DATA FOR OTHER STATE AND LOCAL STRUCTURES

Type of Structure	Source of initial stock (1946)	Sources for gross additions to capital stock after 1946	Source of depreciation rate
	The capital stock in 1946 was created from new construction put in place 1915-1946. A separate capital stock was created for buildings and nonbuilding structures, then these were added for 1946. Constant dollar construction put in place for these two types of structure was estimated as follows: We started with state and local construction in current dollars from [9]. This was deflated to 1947-1949 prices using an implicit price deflator for all public construction) federal and state) from [10]. This produced state and local construction in 1947 to 1949 dollars, which was then converted to 1972 dollars using the GNP deflator for state and local construction for 1946 from [11]. The result, public construction in 1972 dollars, was divided between buildings and nonbuilding structures using the 1947 share	State and local construction put in place in current dollars [5] deflated by the GNP deflator for state and local construction [2]. The deflated series was then decreased by constant dollar sewer system construction.	A weighted average of the depreciation rates for buildings and nonbuilding construction. For buildings we used a 6.6 percent annual rate, the same as used elsewhere in the study for commercial buildings. For nonbuilding construction we used 4 percent, the same as for sewer lines. To construct the initial capital stock (1946), we created separate stocks for buildings and nonbuildings. The weights on the depreciation rates Xere the share of each capital stock in the 1946 total. The weighted average depreciation rate is 4.5 percent.

TABLE 12 - continued

Type of Structure	Source of initial stock (1946)	Sources for gross additions to capital stock after 1946	Source of depreciation rate
	of buildings in state and local construction [3]. The result was an estimate of state and local building and nonbuilding construction 1915-1946. We created two capital stocks, starting with an initial stock in 1915 [4], one for building, one for nonbuilding construction. The total initial stock was decreased by the 1946 stock of sewers.		
Stock of federal grants-in-aid	Calculated from federal grants between 1915-1946. Grants-in-aid in current dollars are from [6]. These are deflated by the implicit deflator for state and local construction less sewers. This deflator was formed by dividing current expenditure by constant dollar expenditure (1972 dollars). Current and constant dollar data on state and local construction from [7]. Current and constant dollar data on sewer construction from [8]. The deflated expenditures were summed from 1915 to 1946, each year subtracting depreciation at 4.5 percent of the previous stock.	Calculated by deflating current grants-in-aid less sewer systems. Current dollar grants-in-aid: from 1947-1962 [8]; 1963-1966 [9]. After 1966, the series was discontinued. After 1966, we assumed it moved in proportion to another series on grants-in-aid, in [10]. Grants-in-aid for sewer systems described above were subtracted.	

TABLE 12 - continued

1. U.S. Department of Commerce, Bureau of the Census, Historical Statistics of the United States, Colonial Times to 1957, Government Printing Office, Washington, D.C. 1960, pp. 379-380, Series N17 and pp 381-382, Series N42

2. U.S. Department of Commerce, Bureau of Economic Analysis, The National Income and Product Accounts of the United States 1929-74, Government Printing Office, Washington, D.C., p. 118, table 3.7, line 15 and p. 120, table 3.8, line 15.

3. Construction Review, December 1976, p. 13.

4. The 1915 end-of-year capital stocks for buildings and other structures were estimated from new construction put in place (I_t) and the assumption that the rate of decpreciation and the growth of the capital stock has been constant. Under these assumptions, it can be shown that

   $$K_{t-1} = I_t/(\delta+g) \qquad \text{(i)}$$

   where δ is the rate of depreciation
   g is the rate of growth of the capital stock

   Equation (i) can be derived from (ii) and (iii) below.

   $$K_t = (1+g)K_{t-1} . \qquad \text{(ii)}$$

   $$K_t = I_t + (1-\delta)K_{t-1} . \qquad \text{(iii)}$$

   Equation (i) implies tht investment must grow at the same rate as capital. Therefore, the rate of growth of the capital stock (g) can be estimated from the rate of growth of investment. We estimated the latter as .0431, the coefficient of a regression from 1915 to 1930. The dependent variable is the natural logarithm of new state and local construction put in place in 1972 dollars. The independent variable is time.

5. 1947-1971: Construction Review, December 1976, p. 13. 1972-1975: Value of New Construction Put in Place, pp. 38-42.

TABLE 12 - continued

6. Historical Statistics, p. 382, Series N58.
7. Historical Statistics, p. 382, Series N57 plus Series N58
8. Historical Statistics, p. 382, Series N57 and Historical Statistics of the United States: Continuation to 1962 and Revisions, p. 56, Series N57.
9. Statistical Abstract, 1968, p. 695.
10. Federal grants-in-aid to state and local governments were summed in the following categories: Waste treatment and pollution control, highway programs, airports, urban mass transit, urban renewal. Data from Statistical Abstract, 1971, p. 401 and Statistical Abstract, 1976, p. 262.

TABLE 13

DATA SOURCES FOR DETERMINANTS OF STATE AND LOCAL CONSTRUCTION

Variable	Data Source
Relative user cost	Formula: $V(\theta+r)/PD$ symbols defined below).
Price (V): State and local construction less sewer systems	Implicit deflator. Calculated by dividing current state and local construction [2] (less sewers) by 1972 dollar state and local construction [3] less sewers.
Interest rate (r) on state and local bonds	TROLL Computer System; original data is yield on AAA municipal bonds, from Moody's Bond Survey.
GNP deflator for disposable income (PD)	Disposable income divided by income in 1976 dollars [4]
Stock of residential structures in 1972 dollars	Described elsewhere in this report
Depreciation (θ)	See preceding table
Population	TROLL data bank. For similar data see [5].
Percent of population of school age (age 5 through 19)	Same as above
Per capita income	Gross national product (1972 dollars) divided by population. GNP is from the TROLL data bank. Similar data is in [6].

TABLE 13 - continued

1. U.S. Department of Commerce, Domestic and International Business Administration and Bureau of Domestic Commerce, Construction Review, December 1976 (Vol. 22, No. 10), page 12. The source yields a deflator base 1967, which we converted to base 1972. Data for 1972 to 1976, from U.S. Department of Commerce, Bureau of the Census, Value of New Construction Put in Place (Construction Report C30), May 1977, p. 7-11; p. 23-27.

2. Ibid., p. 13.

3. State and local construction, in 1972 dollars, was constructed by deflating current dollar construction put in place by the GNP deflator for state and local construction. This deflator used information in the following sources:

   U.S. Departmentof Commerce, Bureau of Economic Analysis, The National Income and Product Accounts of the United States, 1929-74, Statistical Tables, p. 118-19, table 3.7, line 15; p. 120-121, table 3.8, line 15.

   (1973-1975) U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1977 (Vol. 57, No. 7), p. 33, tables 3.7 and 3.8.

4. Economic Report of the President, 1977, Government Printing Office, Washington, D.C., p. 213.

5. Ibid., p. 217.

6. Ibid., p. 188.

price index for each and then combined them into one index by weighting each by its share in 1973 state and local construction. The weights for the price indexes are presented in table 14.

The equation for the price of state and local structures was estimated using annual data 1948 to 1975. Least squares estimates, corrected for serial correlation, are shown in table 15.

THE CONSTRUCTION LABOR MARKET

One of the major effects of increasing construction is to increase the demand for particular occupations within the constuction industry. The discussion and statistical work in this section focuses on the extent to which EPA grants and regulations will generate extra employment in particular occupations, the extent to which these demands can be accommodated by the numbers of workers currently in each occupation, and the ease with which new workers can be drawn in. We then turn to the effects on wages.

The Market for Specific Occupations

The term "construction workers" covers a number of different occupations and skill levels. The least skilled are "laborers," comprising about one-third of those employed in the industry. All other workers are counted as skilled craftsmen: carpenters, bricklayers, cement finishers, electricians, painters, plumbers, operating engineers (who handle heavy machinery such as cranes and earth moving equipment), and ironworkers (who place reinforcing steel and erect steel structures). The absolute and relative frequency of each occupation is presented in table 16.

The Brookings Institution has questioned whether annual construction of sewage treatment plants can expand by 65 percent to match the availability of EPA's construction grant funds.[1]

Clearly, concern that the industry can not absorb the funds is based on the premises that wages can not adjust to alleviate skill shortages, and that construction of sewage treatment plants uses skills sharply different from those in construction as a whole. It turns out, however, that the extra demands for specific

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[1] Edwin R. Fried, et al, Setting National Priorities, The 1974 Budget, Brookings, Washington, D.C., 1974, p. 257.

TABLE 14

WEIGHTS FOR INDEX OF INPUT PRICE: STATE AND LOCAL CONSTRUCTION LESS SEWER SYSTEM CONSTRUCTION[a]

	Year of survey	Sum of weights	On-site labor	Materials	Equipment	Overhead and profit
Buildings[b]	1965	1	.258	.542	.010	.190
Nonbuildings[c]	1973	1	.246	.445	.110	.199

---

[a] Source: The weights are shown as including overhead and profit. To construct the Laspeyres index, we omitted this category and adjusted the other weights to add to unity. Overhead and profit was represented by multiplying the Laspeyres index by 1+r, where r is the short term interest rate on business loans from Economic Report of the President, January 1977, p. 260, column 7.

[b] Source: State and local buildings included a number of different categories. Since the largest category is educational buildings, we used the input share for elementary and secondary schools reported in U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 1892, "Labor and Material Requirements for Private Multifamily Housing Construction," GPO, Washington, D.C., 1976. This bulletin contains a summary of earlier construction surveys by BLS on pages 23 and 24.

[c] Source: For state and local construction other than buildings, we used input shares for Federally Aided Highways. The BLS survey (1973) for highways is summarized in the source referred to in (a) above. The survey for highways did not break out contractor's equipment but included it in overhead and profit. Hence, the equipment share was estimated from U.S. Deparment of Commerce, Bureau of the Census, 1972 Census of Construction Industries, Industry Series, United States Summary (CC72-I-1), GPO, Washington, D.C., 1975, pp 1-8 and 1-9. The share of construction equipment was estimated as the ratio of capital expenditures plus payments for rental equipment to total construction receipts for SIC 1611.

TABLE 15

DETERMINANTS OF THE PRICE OF STATE AND LOCAL CONSTRUCTION

Dependent variable: Log (GNP deflator for state and local construction less sewer system construction[a])

Explanatory variable	Coefficient	t-value
intercept	.11	1.7
log (index of input prices)	.83	6.7
lagged dependent variable	.14	1.2

R^2	.82
D.W.	1.77
$\hat{\rho}$	.90

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[a] The deflator is formed as the ratio of local construction (less sewers) to state and local construction in constant (1972) dollars. Data on state and local construction in current and constant dollars are included in U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts, 1929-74, Statistical Tables*, pp. 118-121. For 1974-1976, data are included in *Survey of Current Business*, July 1977, p. 33. The corresponding series for sewer systems are presented in *National Income and Product Accounts*, pp 166-169 and *Survey of Current Business*, July 1977, pp 40-41.

TABLE 16

ESTIMATED EMPLOYMENT IN SELECTED OCCUPATIONS IN THE CONSTRUCTION INDUSTRY, 1970

	Total employment (thousand)	Percent
Total Construction Craftsmen	1,950	71
Carpenters	650	24
Bricklayers	175	6
Cement Finishers	60	2
Electricians	190	7
Operating Engineers	240	9
Painters	270	10
Plumbers	225	8
Ironworkers	55	2
Other Craftsmen	85	3
Laborers	815	29
TOTAL	2,765	

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Manpower Implications of Alternative Levels of Sewer Works Construction," (processed), December 1973, p. 21, table 5.

skills are not large as a fraction of current employment, and within each occupation, employment associated with construction of sewer systems is a minor fraction of total employment and would remain so even if sewer system employment were to double.

Projections of demand by occupation will be presented later in this paper. For now, we review results of a BLS survey conducted in 1970 and present these results adjusted to 1976. Table 17 presents employment in sewer works by occupation in 1970 and 1976 as a percentage of total employment. In no category is this percentage large. Even for operating engineers, where the estimated percentage exceeds 10 percent, the percentage needs to be adjusted downward. The reason is that operating engineers are less important for treatment plants than for sewer lines, and since the survey was performed, the mix of sewer system construction has shifted toward treatment plants. The adjustment for the changed mix is made in our statistical projections.

Two more points should be made about the availability of construction labor. First, as shown in table 18, the unemployment rate in construction is chronically high. Although this seems to indicate that labor is always available, it is not so. The unemployment rate is typically higher in construction than in nonagricultural employment in general or in manufacturing in particular. Even when construction demand is heavy and shortages are reported, unemployment rarely falls below 7 percent. Similar conditions in manufacturing lead to unemployment of about 3 percent. When demand is weak, unemployment in construction rises as high as 18 percent compared to 11 percent in manufacturing.

One reason for the high rate of unemployment in construction is that the work is seasonal. In 1968, a year of strong demand, unemployment was 4.2 in August but 12.5 in February. Classen has shown that construction workers are compensated for this seasonality with higher wages.[1] Moreover, construction tends to be subsidized by the unemployment insurance system. Because of seasonality, construction workers typically receive twice as much in benefits as their employers pay into the system.

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[1] Kathleen Classen, "The Distributional Effects of Unemployment Insurance," Professional Paper 198, Public Research Institute, Arlington, Virginia, September 1977.

TABLE 17

ESTIMATED EMPLOYMENT BY OCCUPATION IN SEWER SYSTEM CONSTRUCTION, 1970 AND 1976

	Employment in sewer works as a percent of total employment in construction	
	1970	1976
Total Craftsmen	1.5	3.16
Carpenters	.92	1.92
Bricklayers	.6	1.24
Cement Finishers	2.06	4.35
Electricians	.8	1.66
Operating Engineers	5.7	11.91
Painters and paperhangers	.2	.43
Plumbers	1.02	2.14
Ironworkers	3.7	7.65
Laborers	2.8	5.89

The table was derived using the following basic data:

Employment in the construction industry 1970: U.S. Department of Labor, Bureau of Labor Statistics, "Manpower Implications of Alternative Levels of Sewer Works Construction," Processed December 1973, p. 21, table 5.

Employment of Construction Workers on Sewer Systems, 1971: *Ibid*., p. 16, table 3.

New Construction Put in Place, Total and Sewer Works: U.S. Department of Commerce, Bureau of the Census, *Value of New Construction Put in Place*, May 7, Construction Reports (30-77-5), pp. 28, 29, and 34.

TABLE 18

UNEMPLOYMENT RATES FOR NONAGRICULTURAL WORKERS, CONSTRUCTION WORKERS AND MANUFACTURING WORKERS

Year	Unemployment Rate (%) Nonagricultural	Construction	Manufacturing
1948	4.5	8.7	4.2
1949	7.3	13.9	8.0
1950	3.9	12.2	6.2
1951	3.9	7.2	3.8
1952	3.6	6.7	3.5
1953	3.4	7.2	3.1
1954	6.7	12.9	7.1
1955	5.1	10.9	4.7
1956	4.7	10.0	4.7
1957	4.9	10.9	5.1
1958	7.9	15.3	9.3
1959	6.1	12.4	6.1
1960	6.2	13.5	6.2
1961	7.5	15.7	7.8
1962	6.1	13.5	5.8
1963	6.1	13.3	5.7
1964	5.4	11.2	5.0
1965	4.6	10.1	4.0
1966	3.8	8.0	3.2
1967	3.9	7.4	3.6
1968	3.6	6.9	3.3
1969	3.5	6.0	3.3
1970	5.2	9.7	5.6
1971	6.2	10.4	6.8
1972	5.7	10.3	5.6
1973	4.8	8.8	4.3
1974	5.7	10.6	5.7
1975	9.2	18.1	10.9

SOURCES:
1. U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics, 1975, Reference Edition, p. 172.
2. U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1977 (Volume 57, Number 7), pp. 3-13.

Though the unemployment rate gives a misleading indication of tightness of the construction labor market relative to other markets, it can be used as an indicator of tightness relative to historical standards. Thus, in 1975, we can conclude that labor was readily available; unemployment was over 18 percent, more than twice its level when demand is high.

A final point about the availability of construction labor is that the long-run shortages predicted in the past have not materialized. Predictions were often based on the observation that apprenticeships were too few to replace workers expected to retire. Yet construction has continued to expand without severe manpower shortages.[1]

One reason these predictions failed is that apprenticeship is not the only way to become a craftsman. Many of the skills necessary can be obtained by on-the-job training or in manufacturing. In a union project, becoming a journeyman requires union approval. Still, according to Mills, "union membership is not normally denied to men who have mastered the craft, no matter how they have learned it."[2]

Construction workers typically move between occupations. The extent of this movement can be estimated from micreconomic data compiled from Social Security records. These data show a steady movement in the construction industry, from less skilled to more skilled professions. When starting in a new craft, these workers will noD be completely trained, but they will have experience in the construction industry. Table 19 shows the fraction of new hires in each branch of the construction industry with previous experience in another branch of construction. Though these subindustries do not exactly describe occupations, they do represent firms which specialize in providing workers of a particular occupation. For example, the subindustry titled "plumbing" hires some workers

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[1] Herbert R. Northup and Howard G. Foster, Open Shop Construction, University of Pennsylvania, Philadelphia, 1975, p. 221.

[2] Mills, Industrial Relations and Manpower in Construction, MIT Press, Cambridge, 1972, p. 310.

TABLE 19

PERCENT OF EMPLOYEES ENTERING A SUBINDUSTRY WHO HAD EXPERIENCE ELSEWHERE IN CONSTRUCTION

Standard Industrial Classification (SIC)		
151	General contractors	36
	Heavy construction:	
161	Highways	47
162	Other heavy construction (includes sewer systems)	48
171	Plumbing	51
172	Painting	55
173	Electrical	41
174	Masonry	53
175	Carpentry	58
176	Roofing	49
177	Concrete	58
179	Misc. special trades	54

SOURCE: Tabulations from Social Security Records besides plumbers, but still specializes in providing plumbing services.

The table suggests that a new construction worker will tend to begin by working for a general contractor. Then, as his skills begin to develop, he will move to a heavy construction firm or to a special trade contractor. Government expenditures that place special demand on heavy construction or on the special trades will tend to draw workers from other subindustries. If skill reservoirs are depleted, the depletion will be general, not just in the subindustries directly affected by the government expenditures.

Wage Determination

One concern about added demand in the construction industry is that it will touch off increases in construction wages. This concern is based on the premise that excess demand is an important explanation of wage changes. The plausibility of this premise can be gauged by considering these and other explanations for the rapid rise of construction wages since the mid-1960s and by statistical work presented later.

A number of explanations have been offered for the swift rise of wages:

- the low rate of construction unemployment in the 1960s
- wage increases in alternative employment
- union behavior
- the prevailing wage doctrine specified by the Davis-Bacon Act.

Excess demand for construction labor during the late 1960s, as measured by a low unemployment rate, provides the most straightforward explanation of the increase in the construction wage. From 1966 to 1970, the unemployment rate in contract construction was below 10 percent. This was the longest period of low unemployment since the war, and the first period of unemployment below 10 percent since the early 1950s. (See table 18, above.)

The protracted economic expansion of the late 1960s led to heavy demand for manufacturing workers and rising wages. Even when demand for manufacturing labor fell in the early 1970s, manufacturing wages rose. Waiting for high paying manufacturing jobs may continue to be an attractive alternative to construction employment, especially given the availability of increased unemployment benefits during the wait.

Union behavior in general and wage leadership in particular may also have contributed to the rapid increase of wages. The theory is that a heavy demand in the area for, say, plumbers, leads to an increase in wages. Plumbers in other areas, and other craftsmen in the same area, conclude that they can, or must, extract similar gains. Wage increases thus spread from area to area and from craft to craft.

This theory has been proposed, tested and accepted by Mills.[1] As a measure of the pressure for catch-up wage increases, Mills uses the dispersion of wage gains within the same city for different crafts. The theory, and the measure of wage dispersion, grew out of Mills' perception that his earlier work did not explain the momentum that wages had picked up in the 1970s.

The theory attributes great importance to unions, and the importance of unions in construction argues in its favor. Northrup and Foster conclude that construction is about 50 percent unionized, but that the unionized sector has suffered major losses in recent years.[2] Unions are strongest in the north and west, especially in large cities; they are strong in industrial construction, and are weak in residential construction. Recent losses have been sharpest in commercial building.

Not only are construction unions strong, they are prone to strike. In most years, the proportion of work days lost to strikes is higher in construction than in other industries. On the other hand, strikes, once they occur, are less serious in construction than they might seem at first. Labor laws have been written to prevent an entire project from being closed down when only a single union is on strike. The law provides that other unions can not honor a picket line, since this would be a secondary boycott. An attempt to remove this restriction failed to override a veto by President Ford in 1975.

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[1] Daniel Quinn Mills, "Explaining Pay Increases in Construction," Industrial Relations, May 1974 (Vol. 13, No. 2), pp. 196-201.

[2] Herbert R. Northrup and Howard G. Foster, Open Shop Construction, University of Pennsylvania, Philadelphia, 1978, pp. 79-93.

The theory that the rapid wage increases of the 1960s are due to unions is questionable: it requires that union members be willing to accept potentially large increases in unemployment to match other unions. Indeed, as will be shown later, a 10 percent wage increse would reduce employment by about 6.5 percent, even before accounting for further decreases due to higher construction prices and lowered demand. Still, the union's goals need not be purely monetary. Equivalence with other unions may have some role.

A final hypothesis is that the continuing increase in construction wages is due to the administration of the Davis-Bacon Act. The Act, originally passed in 1931, specifies that workers employed in every construction contract over $2,000 to which the federal government is a party must be paid locally prevailing wages. Note that the Act applies not only to federal construction but to any state and local construction built, even in part, with federal grants-in-aid. Each new grant-in-aid law includes a stipulation that Davis-Bacon applies.[1] Perhaps the strongest impact is in highway construction. Mills argues that:

> "The impact of Davis-Bacon is most pronounced in highway construction, where federal funds are a major proportion of total construction dollars. Davis-Bacon has made union organization easier in this branch of the industry and has probably contributed to a rising level of wages. Its impact on other branches is far less significant."[2]

Since sewer system construction is now subsidized heavily by the federal government, the impact of the Davis-Bacon Act applies to most of this type of construction.

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[1] John P. Gould, Davis-Bacon Act -- The Economics of Prevailing Wage Laws, American Enterprise Institute, Washington, D.C., 1971 (Special Analysis Number 15), page 7.

[2] David Quinn Mills, Industrial Relations and Manpower in Construction, MIT Press, Cambridge, 1972, page 82.

The Davis-Bacon Act could have explained the increase in wages if the types of construction covered by the law had been increasing in importance, or if the administration of the law had been tightening. The first possibility has not occurred. As can be seen from table 20, there is not a steady upward trend in the share of federal construction and grants-in-aid in total construction. Little can be said about whether the law's administration is becoming more stringent. However, there is some evidence that the presence of the Act does raise wages.

The local "prevailing wages" that must be paid are determined by the Labor Department on the basis of what is called the 30 percent rule. The rule defines the prevailing rate as that paid to a plurality of workers in the area, so long as that number exceeds 30 percent of the work force. In practice, since a whole range of wages may exist at any time in a single locality, this rule strongly favors the union wage, which is usually the modal wage, even though it often far exceeds the average wage.[1] According to Gould, the General Accounting Office has conducted six studies, documenting repeatedly that the Labor Department's determination "has been unreasonably high." In at least one instance, the union wage rate was applied despite a wage survey that indicated an average wage well below the union wage.[2] In one of the GAO studies it is reported that the Department of Labor determinations were 33 percent above average wage rates in the area.[3] Note that this is a direct consequence of defining the "prevailing wage" as the most common, rather than the average wage.

The Demand for Labor

The added construction due to environmental regulations will increase demand for construction labor in general, but this increase in demand will be greater in some trades than in others. Therefore, we estimate how the demand for labor will change in each trade. In deriving these estimates, we are subject to a major limitation of the time series data, that employment data

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[1] Herbert R. Northrup and Howard G. Foster, Open Shop Construction, University of Pennsylvania, Philadelphia, 1975, page 309.

[2] Gould, op. cit., pages 11 to 15.

[3] Gould, op. cit., page 14.

TABLE 20

THE SHARES IN TOTAL CONSTRUCTION OF FEDERAL CONSTRUCTION PLUS GRANTS-IN-AID

Year	Percentage share
1947	6.4%
1948	6.3
1949	7.6
1950	6.9
1951	10.3
1952	13.5
1953	13.0
1954	10.8
1955	8.4
1956	8.0
1957	9.0
1958	11.5
1959	12.0
1960	11.3
1961	11.7
1962	11.2
1963	11.3
1964	11.3
1965	10.2
1966	10.0
1967	9.4
1968	8.5
1969	8.2
1970	8.4
1971	8.3
1972	7.7
1973	7.4
1974	8.3
1975	10.2

Sources: Federal Construction and Total Construction, Construction Review, Dec. 1976. Grants-in-aid, see table 12, notes 8,9,10. The three series are expressed in 1972 dollars before percentages are calculated.

are not available by occupation. To deal with this limitation, we make use of a technique which combines input-output coefficients with statistical estimates of the response of demand to price and wage changes. This allows us to adjust for substitution between labor and nonlabor factors of production, but not for wage induced substitution between trades. We start the description of the method with a description of the input-output technique, then turn to how it is combined with statistical estimation.

The Input-Output Technique

The input-output coefficient A_{ij} is the quantity of labor in trade i used to produce one unit of structure type j. The demand for labor derived purely from input-output is thus:

$$X_{ij} = A_{ij}Q_j, \tag{11}$$

where

X_{ij} is the quantity of labor (in hours) in trade i engaged in building structures of type j.

Q_j is construction of type j, measured in 1972 dollars.

The demand for labor shown above is based on the assumption that labor and non-labor inputs have a zero elasticity of substitution. We relax this assumption to allow a nonzero, but still constant, elasticity of substitution between labor and other inputs. However, we maintain the assumption that, for any given type of construction, the composition of construction between trades is fixed.

The assumption of fixed composition between trades is written:

$$X_{ij} = b_{ij}X_j \tag{12}$$

where X_j is total employment associated with structure type j. Note that this formulation still allows total employment within a trade to vary in response to the mix of construction between different types of structure.

The above equation is combined with a specification of total employment, by structure, which allows for a nonzero elasticity of substitution between labor and other inputs and gradual adjustment of labor demand to output changes. Denoting the elasticity of substitution as σ and assuming constant returns to scale, the desired quantity of labor (X_j^*) used to build structure j is

$$X_j^* = B_j Q_j \left[\frac{P_j}{W_j}\right]^{\sigma} \qquad (13)$$

where:

P_j is the price of structure j

W_j is the average per hour wage for workers on structure j.

We assume that actual demand for labor (X_j) is a function of the desired quantity, current and lagged one period:

$$X_j = X_j^* \lambda (LX_j^*)^{(1-\lambda)} \qquad (14)$$

where LX_j^* is X_j^* lagged one period. Eliminating X_j^* and LX_j^*, which are unobservable, we obtain:

$$X_j = B_j Q_j^{\lambda} \left(\frac{P_j}{W_j}\right)^{\lambda\sigma} (LQ_j)^{(1-\lambda)} \left(\frac{LP_j}{LW_j}\right)^{(1-\lambda)\sigma} \qquad (15)$$

Once the parameters B_j, λ and σ are estimated, equations of form (15) can be used along with equations of form (12) to calculate the demand for labor in each structure. From demand for labor by structure, demand by trade can be estimated.

Statistical Estimation

What remains is to estimate parameters. Estimates of the input-output parameters B_j and b_{ij} are obtained directly from surveys of labor requirements. Estimates of the parameters σ and λ are derived from statistical estimation on annual time series data. To derive a form suitable for estimation using the employment data available, namely total employment, we sum equation (15) across all types of structure j. Assuming that the parameters σ and λ are the same for each structure, the equation to be estimated is

$$X = \alpha \sum_j B_j Q_j^{\lambda} \left(\frac{P_j}{W_j}\right)^{\lambda\sigma} (LQ_j)^{(1-\lambda)} \left(\frac{LP_j}{LW_j}\right)^{(1-\lambda)\sigma} \qquad (16)$$

The new constant α measures the extent to which the rest of the right hand side predicts the average level of aggregate employment. If the average is predicted perfectly, α will be unity.

Sources of Data

For most types of construction, estimates of input-output coefficients are taken from a recent RAND study[1] which presents estimates of the number of man-hours of labor per $1000 of construction. Detail is available by trade and by type of construction, though some types of structure are not covered. The estimates are derived from a number of surveys performed by the Bureau of Labor Statistics. The BLS surveys were performed in different years and labor requirements per $1000 correspond to different price levels for different surveys. The RAND study has adjusted the BLS results into a common base year, 1974.

Labor requirements per $1000 are readily converted to input-output coefficients. It will be recalled that one set of coefficients, (b_{ij}) represents the share of each trade (i) in total labor requirements for structure j. This share is calculated directly from requirements per $1000 by dividing man-hour requirements for each trade and type of structure by total man-hour requirements for the type of structure.

The other input-output coefficient, B_j, is the number of total man-hours in all trades per unit new construction of structure j. Since we are measuring the quantity of structure j by the value in 1974 dollars, the coefficient B_j is the number of man-hours per 1974 dollar, a magnitude available directly from the RAND report. Note that this definition of B_j implies specific units for measuring the variables on the right-hand side of equation 16. Output Q is measured by the value put in place in 1974 dollars. Both P_j

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[1] George Vernez, et al., Regional Cycles and Employment Effects of Public Works Investments, RAND, Santa Monica, California, January 1977, pp. 113-114.

and W_j are measured as indices, with 1974 equal to unity.

Table 21, referring to sewer lines, illustrates the type of data available from RAND. For treatment plants, the other category of sewer system construction, more recent and detailed information is available. A detailed description of man-hour requirements for a treatment plant with a daily capacity of 10 million gallons per day was provided by R.L. Michel of EPA. These requirements are listed in table 22.

TABLE 21

MAN-HOURS PER $1000 (1974) OF TOTAL CONSTRUCTION COST IN SEWER LINES

Trade	Man-hour requirements
Bricklayer	.6
Carpenter	1.1
Cement finisher	.2
Electrician	.1
Equipment operator	8.5
Ironworker	.2
Laborer or apprentice	18.8
Painter	---
Plumber or pipefitter	.2
Other skilled labor	8.8

Source: Vernez, et al, op. cit.

The other variables in the equation to be estimated are the value of new construction put in place (in constant dollars), and indexes of wages and of the price of new construction. Each variable is needed by type of new construction. Data for the value of construction and the prices of structures are from Construction Review. Other prices appearing in the equation are from the national income accounts. Detail is provided in tables 1 and 2 earlier, and the surrounding text. Regardless of the type of structure, wages were measured by the BLS series on average hourly earnings in contract construction.[1] The dependent variable, the quantity of labor, was measured by total employment in contract construction, multiplied by average hours per week.[2]

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[1] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, 1909-1975 (BLS Bulletin 1312-10), Government Printing Office, Washington, D.C., 1975.

[2] Same sources as above.

TABLE 22

MAN-HOURS PER $1000 (1976) OF TOTAL CONSTRUCTION COST IN SEWAGE TREATMENT PLANTS[a]

Trade	Man-Hour Requirements
Apprentice or laborer	4.65
Cement finisher	1.64
Electrician	.86
Pipefitter	1.09
Power crane operator	.98
Reenforcing ironworker	3.30
Carpenter	14.55
Teamster	1.00
Tractor operator	1.20
Other skilled	4.50
Total	33.77

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[a] Adjusted so that construction excludes purchased equipment.

Sources: Man-hours per $1000 of expense, including purchased equipment from Environmental Protection Agency, Municipal Construction Division, "Summary of Work on Contract 68-01-1693, Mod. 3, with ICARUS Corp.: Resource Utilization in Construction of New and Upgraded Municipal Wastewater Treatment Plants," Memo by R. L. Michel, Dec. 16, 1976.

Share of Expense sccounted for by equipment obtained from R.L. Michel, "Different Methods of Calculating On-Site Direct Labor Man-Years for Construction of Municipal Wastewater Treatment Facilities," Environmental Protection Agency, Municipal Construction Division, February 1977.

The Estimated Demand for Labor

Equation 17 (reproduced below) was estimated using annual data from 1949 to 1975. Nonlinear least squares estimates, adjusted for first order serial correlation, are presented in table 23.

$$X = a\sum_{j} B_j Q_j^{\lambda}\left(\frac{P_j}{W_j}\right)^{\lambda\sigma}(LQ)^{(1-\lambda)}\left(\frac{LP_j}{LW_j}\right)^{(1-\lambda)\sigma} \qquad (17)$$

where

X is employment (man-hours)

Q_j is value put in place for structure j, measured in constant (1974) dollars

P_j is the price index of structure j (1974=100)

W_j is the average hourly earnings, index (1974=100)

L indicates a one-period lag

TABLE 23

ESTIMATED DEMAND FOR LABOR

Parameter	Estimated coefficient	t-value
a	1.04	33.2
σ	.70	6.3
λ	.50	5.5

$R^2 = .71$
D.W. = 1.72
$\hat{\rho} = .78$

These results suggest that the long run elasticity of substitution between labor and other factors of production is about .1, and that about 50 percent of the adjustment takes place in the first year. The parameter a is estimated to be 1.04. The small difference from 1 is the extent to which aggregate labor requirements exceed those predicted by the adjusted input-output technique, represented by the right-hand side of the equation. A time trend was tried in a more aggregated version of the equation, but was dropped for lack of effect.

LABOR SUPPLY

Labor supply is affected by unemployment in construction and wage leadership between crafts. This kind of Phillips curve relation emerged from experiments expressing the current wage (W) as a function of the lagged wage (LW), unemployment (U), and manufacturing wages (to represent alternate employment possibilities). The lagged wage entered with a coefficient very close to unity, suggesting we use the change in wages (in logs) as the dependent variable. The manufacturing wage (and alternatively its change) could not compete successfully with a measure of wage leadership (D) between craftsmen in the same city.

The supply equation was of the general form:

$$\frac{W}{LW} = f(\gamma, U, D) \tag{18}$$

The parameter γ is a "critical" level of employment, in the sense that as unemployment approaches this low level, wage increases become huge. With the exception of γ, the equation is similar to ther one estimated by Mills.[1]

Since the unemployment rate appears as a determinant of wages, it must be explained as part of the model. We express unemployment in contract construction as a function of unemployment in other nonagricultural sectors, employment in construction, employment in other nonagricultural employment, and the number of persons in the armed forces. Because the equation for unemployment takes construction employment as given, what is being explained is labor force participation in construction.

Measurement of Variables

The measure of wage leadership, D, was constructed using the same method used by Mills, although Mills calculated it across more cities and skilled trades. The measure describes the degree to which wage increases are different for different crafts and hence, the pressure for catching up. In each of 13 cities, we calculate the percentage wage increase for each craft during the preceding three years. Then, in each year and each city, the variance of these increases around the mean is calculated. Finally, the variances are averaged across the 13 cities to obtain a single time series. This series purports to measure the dispersion of wage increases among crafts and the pressure for catching up of wages. The basic data for this measure are union wages in eight crafts, taken from various issues of Engineering News Record.

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[1] Daniel Quinn Mills, "Explaining Pay Increases in Construction, 1953 to 1972," Industrial Relations, May 1974 (Vol. 13, No. 2), pp. 196-201.

Sources for the other data used in the equation for wages (19) and for unemployment (20) are listed in table 24.

The Estimated Supply of Labor

Equation (19) explaining construction wages was estimated using annual, time series data from 1955 to 1975, the span for which data were available to measure the variable D. The results are shown in table 25.

Equation (20), explaining unemployment, was estimated for the period 1949 to 1975. Results are shown in table 26.

THE FINANCIAL MARKET

The added construction for pollution abatement may displace private expenditure by its effects on interest rates. When municipalities and corporations borrow to purchase the equipment and structures needed for pollution abatement, the extra borrowing bids up interest rates of both taxable and tax exempt bonds. The higher interest rates cause borrowers to cut back theiS plans for adding to industrial capacity and residential building. (We assume no response in the supply of money.)

The Tax Exempt and Taxable Markets

The change in interest rates from environmental expenditure is initiated by changes in borrowing in the markets for tax exempt and taxable bonds. Because tax exempt bonds yield income free from federal income tax, they pay interest rates lower than taxable bonds and attract, primarily, purchasers with high marginal rates of taxation. Generally, the yield on tax exempt bonds is about 30 percent below that in the taxable market, indicating that the marginal buyer has a marginal tax rate of about 30 percent.

TABLE 24

DATA USED TO ESTIMATE AGGREGATE DEMAND FOR CONSTRUCTION LABOR

Symbol	Variable name	Sources
W	Wages in construction, adjusted to include fringe benefits	Average hourly earnings in construction (production workers) multiplied by ratio of total compensation to wages and salaries (all employees). Average hourly earnings: 1947 to 1974 from [1, p. 26], 1975, from [2, p. 88]. Total compensation, contract construction from [4, p. 46].
U	Unemployment rate in contract construction	[5]
D	Variance among trades in wages and fringe benefits	[3] various issues
U_{oth}	Unemployment rate in other nonagricultural industries	[5]
X_{oth}	Other nonagricultural employment	[5]
A	Number of persons in armed forces	[5]

Sources:

[1] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, 1909-1975 (BLS Bulletin 1312-10), Government Printing Office, Washington, D.C., 1975.

[2] U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, March 1976 (Vol. 22, No. 9), Government Printing Office, Washington, D.C.

[3] Engineering News-Record, McGraw-Hill, Inc., New York, New York.

[4] U.S. Department of Commerce, Bureau of Economic Analysis, The National Income and Product Accounts of the United States, 1919-74, U.S. Government Printing Office, Washington, D.C.

[5] TROLL Computer System Data Bank, basic data from BLS.

TABLE 25

THE DETERMINANTS OF WAGES IN CONSTRUCTION

$$(19)\ \log(\frac{W}{LW}) = \alpha + \beta \log(LU-\gamma) + \delta \log D$$

where

W	is wages
LW	is wages lagged one period
LU	is the unemployment rate in contract construction, lagged one period
D	is the measure of dispersion in wage increases

Parameter	Estimated value	t-value
α	.027	1.7
β	-.0216	-2.7
γ	5.4	6.4
δ	.015	7.0

R^2	.91
D.W.	2.2
$\hat{\rho}$	-.68

TABLE 26

THE DETERMINANTS OF THE UNEMPLOYMENT RATE

$$(20)\quad \log(u) = \alpha + \beta\log(U_{oth}) + \gamma\log(X) + \delta\log(X_{oth}) + \eta\log(A)$$

where

U	is the unemployment rate in contract construction
U_{oth}	is the unemployment rate in other nonagricultural industries
X	is employment in contract construction, measured as total man-hours
X_{oth}	is other nonagricultural employment
A	is the number of persons in the armed forces

Parameter	Estimated value	t-value
α	10.6	2.8
β	1.2	7.9
γ	-1.3	-3.2
δ	3.6	3.0
η	-5.5	-2.5

R^2 = .94
D.W. = 2.06
$\hat{\rho}$ = .77

Sources of Tax Exempt Bonds

There are two types of tax exempt bonds: general obligation bonds and revenue bonds. The difference is the source of revenue available to back the bonds. General obligation bonds are secured by general taxes collected in the political subdivision. The only limit is a level of taxation specified when the bond is issued. The municipality is not bound to go beyond this limit to repay the bond. Revenue bonds are not secured by taxes at all, but by revenues from the particular project for which the bonds were issued. For example, the revenues might come from sewerage charges or tolls collected on toll roads or bridges.

Because of their more comprehensive backing, general obligation bonds are considered less risky than revenue bonds by investors, and hence, can offer a lower yield. Municipalities can not use them to finance all of their capital requirements, however, because state governments attempt to limit state and local indebtedness, the interest rate that can be paid, and the procedures that must be followed to ensure that taxpayers have a full opportunity to withhold approval. These state limits can be circumvented by creation of special jurisdictions whose sole purpose is to finance and operate specific projects, or by resort to the higher yield revenue bond. Because revenue bonds require high yields, they are the less preferred alternative and have only been used about one-half as much as the general obligation bond.

Though tax free bonds are usually supplied by municipalities, corporations can sometimes use the tax exempt market when the borrowing is for pollution abatement and when the help of the municipality is available. Since 1969 corporations have been able to finance construction through a special type of industrial bond called a pollution control bond. In fact, the bond is issued by the municipality on behalf of the corporation. The proceeds are then used by the municipality to purchase the structures and equipment used for pollution control, and the corporation leases the facilities. In practice, only large firms use this method of financing because transactions costs are high. Moreover, pollution control bonds can be used only by firms with excellent credit ratings since the financial standing of the firm serves as its collateral.[1]

As a result, only about half the construction funds required for industrial pollution abatement have been raised by issuing tax exempt bonds, and marginal firms have not been much helped.

When a bond is issued, the seller specifies the payment at maturity and the coupon payments (the payments before maturity). The yield, measured as the interest rate that makes the present value of the bond 0, is determined implicitly by the price at which the bond finally sells. Municipalities decide on the plans for construction, how much to borrow, and acceptable schedules for intermediate payments and maturities of the bonds, but they do not supply bonds directly to the public. Instead, they ask for bids on the whole bond issue from underwriters who are middle men in the financial market. Each underwriter's bid includes a specification of how the overall amount of the bond issue is to be split into different maturities, and how much the underwriter will pay the municipality for each maturity. In constructing a bid, the underwriter must consider the transactions costs of marketing the bonds, the expected market prices of the bonds, and the risk generated by possible variation around the price he can sell them for.

The municipality generally chooses as the best bid the one that involves the lowest interest payments. Strangely, the lowest interest bidder is usually selected without reference to when the interest is to be paid and without finding the present value of the interest payments. Of course, municipalities are aware of this imperfection in the selection criterion, but, presumably, they use it for convenience.

Once an underwriter has been selected, he then "unbundles" the debt issue into smaller denominations, generally in units of a few thousand dollars. These bonds of smaller denomination then are sold to the public.

During the process of unbundling and selling, the underwriter has the option of having the bond rated, for a fee, by Moody's or Standard and Poors. The aim is to provide investors with an educated opinion of how risky is the bond. The higher the bond is rated, the lower the risk and the yield. The highest rating is AAA.

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[1] U.S. Environmental Protection Agency, Economic Report: Alternative Methods of Financing Wastewater Treatment, Report to Congress, October 1975, p. IV-49.

Purchasers of Bonds

As might be expected, the demand for municipal bonds is concentrated among those with high marginal tax rates: commercial banks, high income households and fire, and casualty companies. These groups usually account for and 90 percent of purchases, with banks and households accounting for 70 percent, and insurance companies accounting for 20 percent. The split of the first 70 percent between banks and households shifts in response to monetary tightness. When monetary policy is tight or the demand for loans heavy, the interest rate on bank loans rises and banks shift their assets into loans. This shift raises the tax-exempt interest rate (but not as much as the taxable rate), making the tax-exempt bonds more attractive to households. As a result, households hold a higher fraction of tax-exempt bonds and the differential between the taxable interest rate and the tax-free rate will rise.

Equations to Explain Interest Rates

The economic literature includes two types of research aimed at explaining interest rates: flow- of-funds models and partial reduced forms. The first analyzes the determinants of the amount of funds moving from, say, the household sector to commercial banks, then to municipalities. The distinguishing feature of these models is that the data meet specified accounting restrictions; what leaves one sector shows up in another. Within each sector (e.g., commercial banks), supply and demand for bonds and for other credit is specified. Interest rates are projected from the joint solution of these equations for supply and demand. Bosworth and Duesenberry developed the first large scale flow-of-funds model for the the Federal Reserve Bank of Boston.[1] A recent example is a model of long-term interest rates by Benjamin Friedman.[2]

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[1] B. Bosworth and J. S. Duesenberry, "A Flow-of-Funds Model and its Implications," in Issues in Federal Debt Management, Federal Reserve Bank of Boston, Mass., 1973

[2] Benjamin M. Friedman, "Financial Flow Variables, and the Short Run Determination of Long-Term Interest Rates," Journal of Political Economy, August 1977 (Vol. 85, No. 4), pp. 661-690.

The alternate approach to predicting interest rates uses a reduced form of the financial sector. Recent examples of this are the equations for interest rates in the St. Louis model,[1] and the equations investigated by Feldstein and Eckstein.[2]

We chose to use a reduced form. This technique is much more straightforward than the flow of funds technique, which requires an elaborate framework of equations. Moreover, Friedman reports that the reduced form approach fits the data as well as the flow of funds approach.[3]

Equations to be Estimated

The interest rates of primary concern in this model are the corporate bond rate (equation 21) and the rate on tax exempt state and local bonds. Each of these is specified as a function of the stock of debt relative to the money supply and a distributed lag in the rate of inflation. The rate of inflation is entered only following 1960. This convention is based on findings in the literature indicating that the rate of inflation had a much stronger effect on interest rates during the 1960s than it had earlier.[4]

$$r = \alpha + \beta(\text{Debt}/M) + \gamma\Delta(\text{Debt}/M) + \delta_1 ZP + \delta_2 L(ZP) + \delta_3 LL(ZP) \quad (21)$$

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[1] Leonard C. Anderson and Keith Carlson, "The St. Louis Model Revisited," International Economic Review, June 1974 (Vol. 15, No. 2), pp. 305-326.

[2] Martin Feldstein and Otto Eckstein, "The Fundamental Determinants of the Interest Rate," Review of Economics and Statistics, November 1970, pp. 363-375.

[3] Friedman, op cit., p. 687.

[4] William E. Gibson, "Interest Rates and Inflationary Expectations," American Economic Review, December 1972 (Vol. LXII, No. 5), pp. 854-865. See also William P. Yohe and Denis S. Karnosky, "Interest Rates and Price Level Changes," in William Gibson and George G. Kaufman, ed., Monetary Economics: Readings on Current Issues, pp. 352-374, McGraw-Hill, 1971.

where

Debt	is the stock of debt
M	is the money supply
Δ	signifies change
Z	is a dummy variable with value 1 in 1961 and thereafter
P	is the percentage change in the consumer price index
L,LL	signify lags of one year and two years

The equations for the tax exempt bond rate, the mortgage rate, and the rate on short term business loans have the same form (shown in equation 21), with the other rates replacing the corporate bond rate.

Investment (including that for pollution abatement) influences interest rates by increasing debt. The level of debt depends on investment as shown below.

$$\Delta \mathrm{Debti} = \alpha + \beta I + \gamma LI + \delta L(\Delta \mathrm{Debti}) \quad (22)$$

where

Debti	is the stock of debt excluding consumer credit, federal bonds, and short term commercial paper
I	is investment, defined as new construction put in place plus private investment in equipment

The forms of debt excluded from the variable Debti are taken as exogenous.

Definitions of Variables

The variables used in the financial sector are described in table 27.

Estimates of Equations in the Financial Sector

The equations for interest rates were estimated using annual data, 1950 to 1975. Estimation is by least squares, correcting for first order serial correlation. Results are presented in table 28 with t-values in parentheses.

TABLE 27

DEFINITIONS OF FINANCIAL VARIABLES

Symbol	Description	Source
r	Yield on corporate bonds, Moody's AAA	[1]
rm	Yield on high grade municipal bonds (Standard and Poor's).	[1]
Debt	End of year outstanding credit market debt: includes U.S. government securities, state and local obligations, corporate and foreign bonds, mortgates, consumer credit, bank loans, N.E.C., short term paper and other loans. Excludes treasury issues held by the Federal Reserve System.	[2]
M	Money stock including demand deposit, currency, and time deposits at large commercial banks.	[3]
P	The percentage change in the consumer	[1,p.241]
Debti	Debt less consumer credit, short term paper, and U.S. government securities	[2]
I	Investment. Value of new construction put in place plus private investment in producer durable equipment.	[4] [1,p.203]

Source: [1] Economic Report of the President, January 1977, p. 260.

[2] Board of Governors of the Federal Reserve System, Flow of Funds Accounts 1946 to 1975, December 1976, pp. 92-94, 137-139.

[3] TROLL computer system data bank, basic data from the Federal Reserve Board.

[4] Construction Review, December 1976.

TABLE 28

ESTIMATED EQUATIONS FOR INTEREST RATES

	Dependent Variables			
	Corporate bond rate	Municipal bond rate	Mortgage rate	Business loan rate
Intercept	-1.4 (-.81)	-1.9 (1.1)	.7 (.4)	-2.4 (-1.2)
Debt/money stock	1.5 (2.8)	1.3 (2.4)	1.3 (2.1	2.0 (3.2)
Δ(debt/money stock)	1.8 (2.0)	2.3 (2.1)	3.2 (3.1)	3.2 (2.9)
1961 dummy (Z) percentage change in CPI (P)	25.0 (5.3)	15.0 (2.8)	29.6 (5.6)	64.4 (11.6)
ZP, lagged once	6.2 (1.1)	11.0 (1.6)	3.8 (.6)	-8.6 (-1.3)
ZP, lagged twice	23.0 (2.8)	12.0 (1.2)	7.9 (.9)	-23.4 (-2.4)
R^2	.90	.83	.86	.95
D.W.	1.31	1.61	.99	1.45
$\hat{\rho}$	.77	.71	.81	.78

The results indicate that interest rates respond to both the level and the change in the ratio of debt to money stock. Both equations suggest that interest rates were not fully incorporating price changes during the period of study. A rise in the rate of inflation by one percentage point led to a rise in the corporate bond rate of about .5 percentage points and a rise in the municipal bond rate of about .3 percentage points.

The equation for debt is estimated using annual data, 1948 to 1975. Results are shown in table 29.

TABLE 29

ESTIMATED EQUATION FOR OUTSTANDING DEBT

Dependent variable: Net increase in debt outstanding

Variable	Coefficient	t-value
Intercept	-11	-2.4
Gross investment	2.1	10.5
Gross investment, lagged once	-1.9	-8.1
Lagged dependent variable	.51	4.1
R^2	.98	
D.W.	1.8	
$\hat{\rho}$	0	

The results indicate that, in the long run, one dollar increase in investment leads to an increase in debt by about $.40. The long run effect is calculated by setting current investment equal to lagged investment and current debt formation equal to lagged debt formation.

DISAGGREGATE EMPLOYMENT EFFECTS OF CONSTRUCTION EXPENDITURES

The econometric model discussed in the previous chapter analyzes the relation between construction expenditure and employment for the industry as a whole. The effects of increased expenditure, however, will not normally be spread evenly over specialties within the industry or over workers with different characteristics. In this chapter, we discuss how added spending in alternative subclasses of construction, such as highway and street construction, other heavy construction (including sewers) and special trades (plumbing, etc.) affects employment of workers with different characteristics. More specifically, we examine how a hypothetical $100,000 payroll increase in each of four subclasses of construction changes the number, characteristics, and income of construction workers.

Note that in this section, our measure of added demand is payroll rather than new construction put in place, which would include both payroll and expenditures on other factors of production. The use of payroll rather than a more complete indicator of demand does not detract from our main purpose here, to estimate how a given increase in employment is split between workers with different characteristics.

The analysis is based on payroll records of individual workers drawn from Social Security records. These data provide the needed detail, since they include the worker's SIC, experience, age, and location.

Because of the special nature of the data, we can make inferences about how the construction labor market reacts to an increase in demand. We measure:

- the distribution of added payroll by workers' experience, age, and race;
- the extent to which new workers are hired;
- the degree to which workers are hired outside local geographic locations; and
- the extent to which workers already employed in construction increase their hours or days of work.

This information reflects the ability of the construction work force to expand. Because construction is extremely labor intensive and local increases in demand can largely be met only by local production, the flexibility of labor is a key determinant of the degree to which increased demand leads to increased production rather than to increased prices.

This information also provides insight into the effectiveness of EPA sewer projects, other public works, and other construction activity as a vehicle for employment creation and income redistribution. Because this part of the study focuses on the employment and earnings of individual workers,it is possible, for example, to determine if a $100,000 increase in payroll provides ten workers with $10,000 each or fifty workers with $2,000 each.

MEASURES OF RESPONSIVENESS TO DEMAND

Employment construction can be expanded by bringing workers from outside the industry, by upgrading skills of relatively inexperienced construction workers or by increasing hours worked by those already skilled in the industry. In order to determine how increased labor demand is met, the construction work force is disaggregated into three groups:

- completely inexperienced workers--those who never before worked in construction
- moderately experienced construction workers--workers with less than four years of prior experience in the construction industry
- highly experienced construction workers--workers with four or more years experience in construction

In manufacturing, an increase in demand is likely to be evenly distributed across all geographic areas where production takes place. In construction, demand may be high in one area but low in other, nearby, areas. Thus an increase in the demand for experienced construction workers in one area may be met, to an unusually large degree, by hiring workers from areas where demand is slack. To examine this type of geographic mobility, the work force is disaggregated into:

- movers - workers who were employed in a given area in year t but employed elsewhere in year t-1;

- commuters - workers employed in a given labor market in year t but who were primarily employed elsewhere in year t-1;

- nonmovers - workers employed in the given labor market in year t and year t-1.

The change in payroll going to each of the above groups is our primary measure of the response to increased demand. In order to distinguish changes in the number of workers employed from changes in the number of hours worked, we also measure the net change in employment in each group.[1] Information about the net increase in employment, and knowledge of the average earnings of workers in the group in the previous year is used to shed light on the distribution of the payroll increase between additional hours worked and additional men employed.

MEASURING EMPLOYMENT CREATION EFFECTS

To assess how effective increasing construction expenditures might be in increasing employment opportunities for workers who otherwise would have difficulty in finding jobs, we divided the labor force into three age groups:

- young workers--those less than 24 years old
- moderately young workers--those 24-35 years old
- older workers--those more than 35 years old

and into two racial groups:

- white
- nonwhite

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[1] We cannot calculate the increase in the number of workers employed due to the change in demand by simply adding up the number of workers employed in a given year but not employed the year before. A large number of workers would be added to the work force even if demand did not change in order to replace workers leaving due to normal attrition.

MEASUREMENT OF THE EFFECT OF PAYROLL INCREASES ON EMPLOYMENT AND EARNINGS

There are several determinants of how a change in payroll is spread across workers with different characteristics. So that these determinants can be taken into account, we measure their effects on each group from coefficients of a linear regression. The dependent variable is, alternatively, earnings or employment of workers with specified characteristics. The right-hand side variables are the determinants discussed below.

The first determinant is the sector of construction where payroll increases. Other things equal, types of construction requiring more highly skilled workers will find it more difficult to increase man-hours of employment by hiring additional workers than types requiring less skill. To take into account differences in types of construction, we examine construction in four separate Standard Industrial Classifications (SICs). Because SIC categories are based on the major activity of the firms, there is not a one-to-one relation between expenditure on specific types of structure (e.g., housing) and receipts by firms in an SIC category. Some firms specialize in building particular structures, i.e., sewer system construction, but others specialize in supplying workers in a particular trade (e.g., plumbing) rather than a specific product. The SIC breakdown used is shown in table 30. Although some finer breakdowns were possible, the groups involved would have been too small for statistical analyses to produce reliable results.

A second important determinant of employment effects is the tightness of the construction labor market. In slack times, there are likely to be many experienced workers who are not employed in construction but are available for employment. Those who are employed are likely to be working less than full time. Thus, any increase in payroll is most likely to go largely to experienced workers. In periods of tightness, employers must hire inexperienced workers.

A third factor is the overall tightness of the local labor market in general, not just the market for construction labor. If other jobs are difficult to find or lower paying, it should be relatively easy for employers to hire workers with the desired characteristics.

TABLE 30

SEGMENTS OF THE CONSTRUCTION INDUSTRY EXAMINED IN THIS STUDY

SIC	
15XX	General Building Contractors
161X	Highway and Street Construction
162X	Other Heavy Construction (includes sewers, water, public utility structures, bridge and tunnel construction)
17XX	Special Trade Contractors includes such specialties as plumbing electrical work, structural steel erection, painting, carpentry, etc.

We control for the tightness of the construction labor market by introducing the change in construction payroll over the previous five years and the difference between current and prior peak payroll. We use a variety of local labor market variables to control for general labor market tightness.

The effects of an in increase in payroll *originating in one sector* (e.g.,SIC 15) are defined as changes in the employment and payroll of workers in all construction SICs, not just those in the original sector. Although most of the effects are concentrated in the sector where payroll increases, some interaction among sectors probably occurs. For instance, a demand increase in a special trade sector may be met by drawing experienced workers out of the general contracting sector, where, in turn, new workers may be hired.

To examine the aggregate response of employment, across all SIC groups, to an expenditure change originating in only one sector, it is necessary. Control for the change in payroll of other sectors. We do that by entering the payroll of different sectors as separate variables into our estimating equation. We use a single equation to estimate the effect of spending increases in each sector. If the effect of changes in payroll in each sector were estimated by separate equations, the change in that sector's payroll would act as a proxy for the change in total industry payroll and employment effects would appear to be far greater than they actually are.

The basic estimating equation used in the analysis is presented below:

$$\begin{bmatrix} W_j^t \\ P_j^t \end{bmatrix} = a_o + \sum_{i=1}^{4} \Big[b_i . P_i^t + c_i . (P_i^t - P_i^{t-1}) + d_i \, . \, (P_i^t - P_i^{t-5}) + e_i \, . \, (P_i^t - P_i^{t_{max}}) \Big] + \overline{f} \, \overline{X} \qquad (23)$$

where W_j^t = the number of workers in *all* construction sectors in characteristic group j, year t

P_j^t = the payroll for all construction workers in characteristic group j, year t

$\begin{bmatrix} W_j^t \\ P_j^t \end{bmatrix}$ = indicates that the two variables are dependent variables in separate regressions

P_i^t = payroll in construction industry sector i, year t (t_{max} is the maximum payroll prior to year t)

$\bar{X}$ = vector of local labor market characteristics

X_1 = local unemployment rate

X_2 = unemployment in year t as a percent of 1960 unemployment (this is a measure of the state of the business cycle in a local area)

X_3 = average wage in manufacturing

X_4 = change in manufacturing wage over one year

X_5 = change in manufacturing wage over five years

X_6 = total employment

X_7 = change in employment over one year

X_8 = change in employment over five years

X_9 = number of workers in manufacturing

DATA

Information on the detailed characteristics of workers in the construction industry is not available from published sources. This part of the analysis was possible only because of a data set, developed expressly for this study, which was derived from Social Security Logitudinal Employer-Employee Data (LEED). The LEED file describes the age, race, sex, and longitudinal employment history (earnings, location, and industry of employer) of 1 percent of all workers covered by Social Security for 1957 through 1972.

Records of individual construction workers in the thirty largest SMSAs were extracted and tabulated to describe the number of workers employed and the payroll of workers in each construction SIC and each characteristic group, for each year 1962-1971.

The construction industry was large enough that the 1 percent sample produced sufficiently large samples to obtain reliable estimates for the subgroups in the industry.

RESULTS

Equation 23 was estimated using ordinary least squares. Each regression had 300 observations (30 cities x 10 years). The overall explanatory power of the regression was high. The R^2 ranged from .88 to .98.

The local labor market variables were significant in several cases and the effects were generally in the expected direction. In particular, high rates of unemployment and low levels of wages in manufacturing made it easier to hire additional workers.

Payroll in each SIC added substantially to the explanatory power of the equation. Although our primary interest is in the effect of an increase in payroll over the previous year, we can not use the coefficient on this variable alone to make this estimate. Payroll in a given SIC appeared in several terms of the regression, both separately and in combination with the following: previous years' payroll, payroll five years ago, and maximum prior payroll. Collinearity among these different terms made it impossible to make precise estimates of the effect of separate variables (i.e., the change in payroll over the previous year). The effect of an increase of payroll in a given SIC is, therefore, estimated as the sum of the coefficients on the different terms. We did not estimate the standard errors of this sum for every case; computations were made for a few cases to get an idea of the likely standard errors. These computations suggest that the standard errors are quite small.[1]

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[1] The robustness of the specifications shown in equation 23 was also tested by including only subsets of the original variables in the specifications and expressing some of the variables in percentage terms. These changes made very little difference in the final estimates.

The results of the empirical work are summarized in the next several sections. Our main interest is in measurement of the ability of the construction work force to expand. The best measures of this flexibility are the distribution of a hypothetical $100,000 payroll increase across workers with different characteristics, and how the distribution of the increase compares to the pre-existing payroll distribution. We present this information for each set of worker characteristics--experience, mobility, age, and race, in separate sections. These sections also include descriptions of the distribution of new employees, the prior employment distribution, the maximum earnings of new workers and prior average earnings of the work force. This information is used to measure the ability to expand the number of workers employed as opposed to hours or days worked.

The same information is relevant in assessing the redistributional effects of increased construction spending. Assessing employment creation effects, however, is more complex. First the number of aditional workers hired varies across construction sectors. (In contrast, the payroll increase is, by definition, constant across sectors.) Second, a distinction must be made between the number of different workers added and the number of new positions (slots). A separate section is devoted to discussion of the effect of an increase in payroll on the number of workers employed.

The Effect of a Payroll Increase on Workers With Different Amounts of Experience

Table 31 shows how a hypothetical $100,000 increase in payroll and employment would be distributed across groups of workers with different amounts of experience, and the earnings of the additional workers. In interpreting these results, recall that the SIC refers to the industry group receiving the extra demand and that the added employment need not be in this SIC. In this table and all others, dollar figures are in 1972 dollars.

The reader should also keep in mind that this table deals with the distribution of employment. There is considerable variation across SIC groups in the total number of additional workers employed.

TABLE 31

THE EFFECTS OF A $100,000 INCREASE IN PAYROLL ON EXPERIENCE GROUPS

	No Prior Experience			One - Three Years Experience			Four or More Years Experience		
	(1) Payroll distribution (%)	(2) Employment distribution (%)	(3) Average earnings/worker (1972 dollars)	(4) Payroll distribution (%)	(5) Employment distribution (%)	(6) Average earnings/worker (1972 dollars)	(7) Payroll distribution (%)	(8) Employment distribution (%)	(9) Average earnings/worker (1972 dollars)
1. Initial figures	6.1	22.7	1,222	14.7	20.3	3,303	79.2	57.0	6,317
Incremental effect of $100,000 payroll increase			Maximum earnings/added worker			Maximum earnings/added worker			Maximum earnings/added worker
2. SIC 15	12.2	32.3	1,952	12.3	19.0	3,342	75.7	48.7	8,028
3. SIC 161	27.2	41.0	2,665	34.5	36.5	3,803	38.3	22.5	6,853
4. SIC 162	14.5	33.2	1,582	24.0	33.7	3,639	61.3	33.1	3,641
5. SIC 17	11.9	41.0	952	38.3	38.1	3,282	50.0	21.2	3,282

NOTE: Maximum earnings/added worker is total added payroll divided by the number of added workers in each group. It is the maximum earnings/worker, since we implicitly assume none of the added payroll goes to expanding hours of work.

The first row of the table displays the initial distribution of payroll and employment, and initial earnings levels. To determine whether a group expands more than might be expected from its existing share of payroll and employment, the figures in rows two through five should be compared with the figures in the first row.

As might be expected, the share of a $100,000 payroll increase going to inexperienced workers is more than proportional to their share of pre-existing payroll. For example, in SIC 162, 14.5 percent of the added $100,000 payroll goes to workers with no prior experience compared with 6.1 percent of pre-existing payroll. On an absolute basis, however, the largest proportion of the payroll increase always goes to the group with the most experience.

The proportion of increased employment going to workers with no prior experience is as great or greater than the share going to any other group except in SIC 15. In SIC 15, although the largest proportion, 48.7 percent, goes to workers with most experience, the proportion going to workers with no prior experience is still substantial.

Finally, the earnings per worker column displays the maximum possible average earnings of additional workers. (This is the increase in payroll divided by the increase in workers.) Since some of the additional payroll actually goes to increasing hours, comparison between the average earnings per worker in row 1, and the average maximum earnings is an indication of the distribution of payroll between added workers and added hours. It is most likely that additional workers earn less than average workers. Thus, if average earnings are less than maximum average earnings, as they are for workers with the most experience in SIC 15, a considerable fraction of the added payroll must go to increasing hours. If the reverse is true, as in SIC 162 and SIC 17 for the most experienced workers, little of the increase goes to added hours. If the two averages are similar, as in SIC 161 for the most experienced workers, it is difficult to judge the division between hours and man without knowing the average earnings of the additional workers more precisely.

The Effect of a Payroll Increase on Workers with Different Geographic Mobility Patterns

Table 32 displays information about how a $100,000 increase in payroll would be distributed across groups

TABLE 32

THE EFFECTS OF A $100,000 INCREASE IN PAYROLL ON GEOGRAPHIC MOBILITY GROUPS

	Nonmovers			Movers			Commuters		
	(1) Payroll distribution (%)	(2) Employment distribution (%)	(3) Average earnings/worker (1972 dollars)	(4) Payroll distribution (%)	(5) Employment distribution (%)	(6) Average earnings/worker (1972 dollars)	(7) Payroll distribution (%)	(8) Employment distribution (%)	(9) Average earnings/worker (1972 dollars)
1. Initial figures	87.2	74.1	5,354	8.8	9.3	4,362	3.9	16.6	1,157
Incremental effect of $100,000 payroll increase			Maximum earnings/added worker			Maximum earnings/added worker			Maximum earnings/added worker
2. SIC 15	67.6	60.7	5,734	29.8	26.7	5,775	2.7	12.7	1,061
3. SIC 161	85.5	69.9	4,951	8.5	9.8	3,478	5.8	20.2	1,165
4. SIC 162	51.0	54.1	3,487	41.0	25.1	5,977	8.1	21.0	1,905
5. SIC 17	87.3	71.9	3,977	9.3	11.0	1,784	3.4	17.1	653

NOTE: Maximum earnings/added worker is total added payroll divided by the number of added workers in each group. It is the maximum earnings/worker, since we implicitly assume none of the added payroll goes to expanding hours of work.

of workers with different geographic mobility patterns and how additional employment would be distributed across the groups. The format is almost identical to that for table 31.

In the specialty trades (SIC 17) and highway and street construction (SIC 161), most of the payroll increase goes to workers already in the local area. Other heavy construction, SIC 162, is particularly flexible in the geographic source of its work force. This may reflect the tendency of workers in the heavy construction sector to specialize in one type of construction and routinely migrate to areas where jobs are available.

It is not surprising that added payroll often tends to employ local workers, since 87 percent of pre-existing payroll is received by local workers. However, less than 87 percent of the added payroll is received by local workers, so their percentage share declines.

The Effect of a Payroll Increase on Workers in Different Age Groups

Table 33 shows how a $100,000 increase in payroll would be distributed across age groups and how additional employment would be distributed across those groups.

The expansion of the youngest group of workers, those less than 24 years old, is of major interest, since this group is hard to employ. It turns out that this group increases its share of payroll and work force, often substantially, in almost every category. This is inferred from noting that the proportions of added payroll and employment going to young workers exceed their pre-existing proportions of payroll.

These results support the idea that an increase in construction can increase employment of at least one group of workers who often have difficulty finding employment. It should be noted, however, that although many young workers are hired, they generally do not earn a great deal of money. The average earnings of workers under 24 is only about $1668 (in 1972 dollars). The figures in rows 2-4 suggest that the additional workers make even less than average wages. This may reflect the highly seasonal nature of construction activity. Many of the young workers are probably employed only in the summer.

TABLE 33

THE EFFECTS OF A $100,000 INCREASE IN PAYROLL ON AGE GROUPS

	Age Less than 24			Age 24-35			Age Greater than 35		
	(1) Payroll distri-bution (%)	(2) Employ-ment distri-bution (%)	(3) Average earnings/ worker (1972 dollars)	(4) Payroll distri-bution (%)	(5) Employ-ment distri-bution (%)	(6) Average earnings/ worker (1972 dollars)	(7) Payroll distri-bution (%)	(8) Employ-ment distri-bution (%)	(9) Average earnings/ worker (1972 dollars)
1. Initial figures	7.9	21.4	1,668	32.3	32.8	4,483	59.8	45.8	5,943
Incremental effect of $100,000 payroll increase			Maximum earnings/ added worker			Maximum earnings/ added worker			Maximum earnings/ added worker
2. SIC 15	8.3	27.5	1,557	27.6	35.2	4,053	64.1	37.3	8,800
3. SIC 161	12.1	29.6	1,655	18.2	25.7	2,862	69.7	44.7	6,313
4. SIC 162	12.7	32.6	1,419	23.4	32.4	2,640	63.9	35.0	6,664
5. SIC 17	19.8	29.6	2,195	40.1	40.8	3,539	40.1	29.6	3,999

NOTE: Maximum earnings/added worker is total added payroll divided by the number of added workers in each group. It is the maximum earnings/worker, since we implicitly assume none of the added payroll goes to expanding hours of work.

The Effect of a Payroll Increase on Nonwhites

Table 34 shows how a $100,000 increase in payroll would change the employment and earnings of nonwhite and white workers. The proportion of the payroll going to nonwhites is greater than their initial proportion in each SIC group, except 161. This increase is inferred by noting that the proportion of nonwhite in added payroll exceeds 7.3 percent, the corresponding proportion of pre-existing payroll.

The proportion of added employment is well above the corresponding proportion of pre-existing employment in SIC 15. For SIC 162, the gain in employment is roughly what would have been expected from the proportion of pre-existing employment, but for SIC groups 161 and 17, the gain in employment is less than would be expected.

The Effect of a Payroll Increase on the Number of Workers Employed

Line 1 of table 35 shows the number of additional workers employed in a given year as a result of a $100,000 increase in payroll in each of four construction sectors. Examination of the average earnings of additional workers suggests that most of the difference in the number of workers employed is due to differences in the average duration of employment of the additional workers. Differences in the division of additional payroll between hiring additional workers and increasing the amount of employment plays a relatively small role. In general, the greater the number of additional workers employed, the more widely is the payroll increase distributed (and the smaller is the increase in payroll per capita).

In this study we focused on number of different workers actually employed, whether full or part time. If we assume that additional workers would otherwise be unemployed, slots can be used to measure the effect of a payroll increase on the aggregate rate of unemployment.

Table 35 is designed to illustrate the difference between measurement of the number of different workers employed and the number of slots created. Employment and Earnings, published by the Bureau of Labor Statistics, provides information about average weekly earnings in each construction sector over the period in this study. Multiplying average weekly earnings by 52 provides a measure of full-time equivalent earnings. These figures are displayed on line 2 for each sector.

TABLE 34

THE EFFECTS OF A $100,000 INCREASE IN PAYROLL ON NONWHITE WORKERS

	Nonwhite			White		
	(1) Payroll distribution (%)	(2) Employment distribution (%)	(3) Average earnings/worker (1972 dollars)	(4) Payroll distribution (%)	(5) Employment distribution (%)	(6) Average earnings/worker (1972 dollars)
1. Initial figures	7.1	12.4	2,631	92.9	87.6	4,820
Incremental effect of $100,000 payroll increase			Maximum earnings/added worker			Maximum earnings/added worker
2. SIC 15	12.8	27.5	2,411	87.2	72.5	6,206
3. SIC 161	-.8	3.9	—	100.8	96.1	4,244
4. SIC 162	12.0	14.5	3,015	88.0	85.5	3,749
5. SIC 17	14.3	8.3	5,639	85.7	91.7	3,063

NOTE: Maximum earnings/added worker is total added payroll divided by the number of added workers in each group. It is the maximum earnings/worker, since we implicitly assume none of the added payroll goes to expanding hours of work.

TABLE 35

EFFECT OF $100,000 PAYROLL INCREASE ON EACH CONSTRUCTION SECTOR AND NUMBER OF DIFFERENT WORKERS EMPLOYED

	SIC 15 general building contractors	SIC 161 highway & street construction	SIC 162 other heavy construction	SIC 17 special trade contractors
1. Number of additional workers hired given a $100,000 increase in payroll	19.36	24.71	27.45	30.51
2. Average annual earnings of a worker employed 52 weeks (1972 dollars)	9,555	9,945	10,530	10,668
3. Number of full-time slots[a] ($100,000 ÷ line 2)	10.47	10.06	9.49	9.38
4. Number of workers per slot (line 1 ÷ line 3	1.85	2.46	2.89	3.25

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[a] Estimates of slots are based on the assumptions that all new hiring is in the industry where payroll increases, and all payroll goes to hiring of new workers.

We see that average earnings vary only by about 10 percent across industries. If we assume that a payroll increase in given sectors is spent only on workers in that sector and that the entire payroll increase goes to hiring additional workers (rather than increasing hours), a $100,000 payroll increase increases the number of slots by the figures presented on line 3. This works out to approximately ten slots in each case. Even though we can not measure the precise division between hiring additional workers and expanding hours, we know that some of the payroll, perhaps as much as one-third, goes to expanding hours. The number of slots, therefore, must be even lower than is indicated by the figures in line 3. Even if we accept these figures as accurate, it is clear that, as shown on line 4, the number of additional workers hired substantially exceeds the number of slots created.

Estimation of How EPA Mandated Expenditure Affects Workers of Particular Characteristics

We use the estimate in this section to measure the effect of EPA mandated expenditures on workers with particular characteristics. This estimation involves combining the estimates from the econometric model and those from the present analysis of microdata.

We start with the estimates of employment change from the econometric model, then split up these changes in proportion to the relative gains in employment for workers of different characteristics, the latter estimated from the LEED data as reported in this section.

Consider an example. Suppose that in 1978, as estimated in the econometric model, EPA mandated expenditure on sewers (SIC 162) raised employment by 36,120 workers. In the present section, we have estimated that 33.2 percent of an employment increase in SIC 162 goes to hiring workers who have no prior experience. Our estimate of the additional employment of inexperienced workers is, therefore, .332 times 36,120 or 11,992 inexperienced workers.

SUMMARY AND CONCLUSION

In general, the greatest fraction of an increase in payroll is absorbed by highly experienced workers. Relatively few additional workers are hired in this group. Most of the increase goes to those already employed, in the form of more hours or days of employ ment. Some sectors show considerable ability to add additional workers as well. Most of the increase in employment occurs among young, totally inexperienced workers. Geographic mobility is generally not a very important source of additional labor input, except for SIC 162 - heavy construction. Special trade contractors show less ability to absorb demand increases by increasing employment, or payroll, of less experienced workers.

We hypothesized that on average there is usually underemployment of highly experienced construction workers. The above results are consistent with this hypothesis. Substantial increases in demand can be met by increasing hours of highly experienced workers, drawing workers with prior experience into the construction industry, and increasing the number of inexperienced workers; most of the additional demand can lead to additional output, not higher prices.

As far as we can tell, the construction industry is likely to be particularly flexible in meeting the demand for sewer construction and of other heavy construction of the type EPA directly funds.

Finally, based on the evidence presented here, the employment creation effects of an increase in construction payroll is likely to be substantial for the young, inexperienced workers who find it generally difficult to find work. Although such workers may not earn very much relative to average construction workers, the increase in income is likely to be large relative to what they would earn otherwise. Increased spending on heavy construction (SIC 161), which includes sewer construction, is particularly likely to create additional employment.

FINDINGS

The objective of this study has been to determine how the construction industry would respond to the extra demand generated by pollution abatement. To do this, we developed a model of the construction industry and used it to form two alternate forecasts of a number of variables for the period 1976 to 1985. These variables included the value of construction put in place: employment and wages in contract construction, interest rates, and capital costs per unit of new industrial plant. The forecasts take into consideration the state of the national economy. For predictions of the state of the economy, the level of general economic activity and the price level, we relied on Data Resources Incorporated (DRI).

Our two forecasts differed only in their assumptions about environmental requirements and grants. One forecast, called BASELINE, was meant to represent the situation with no EPA requirements for industrial pollution abatement and with no further authorizations under the Construction Grants program beyond those originally made in 1972. The second forecast, called ACTUAL, was meant to represent the situation with existing requirements on industry and with the anticipated level of grants. The difference in the forecasts provides an estimate of the effects of the extra environmental expenditures.

BASELINE projections of expenditures under the Construction Grants program were provided by the Council on Environmental Quality and EPA. The projections for the ACTUAL forecast incorporate the 24.5 billion dollars authorized in December 1977 and a new authorization in 1982 of 20.5 billion dollars, consistent with the administration target, stated in 1977, of 4.5 billion dollars annually for 10 years. Appropriations and expenditures have been well below full authorizations, however. Thus, our projections for expenditures are not based on authorizations, but on the pattern of expenditure set by the actual outlays in 1978 and 1979 and by the OMB forecast for 1980. For example, spending in 1980 is projected to be $3.7 billion, considerably below the authorization of $4.5 billion, but still above the BASELINE expenditure of $2.3 billion.

Projections of industrial expenditures to meet environmental requirements, termed incremental industrial expenditures, were provided by EPA. The projections of grants and industrial expenditures are shown in table 36.

Not all of municipal and business expenditures for pollution abatement are for construction; some expenditures are for the purchase of equipment. Since our interest is limited to construction, we adjusted the expenditure data to represent only construction. The necessary adjustment was estimated from basic data provided in a report by Leung and Klein.[1]

THE EFFECT OF POLLUTION ABATEMENT EXPENDITURES ON TOTAL CONSTRUCTION

The increase in total construction will be less than the increase in the pollution abatement expenditures. Some construction that would otherwise occur will be displaced. Projections of construction expenditures in 1972 dollars are presented in table 37.

Construction goes up between 1976 and 1985 in both the BASELINE and the ACTUAL projections. The precise pattern of the increase derives in part from the forecasts of constant dollar GNP, industrial production, and other measures of economic activity provided by DRI. These forecasts indicate that although GNP (1972 dollars) will increase through 1985, the rate of increase will vary, and it is the change in activity, not the level, that affects new construction. Percentage increases are predicted to be low in 1979, 1981, 1982, and 1985 and high in the other years.

THE EFFECT ON SPECIFIC TYPES OF CONSTRUCTION

The projected additions to construction demand to meet standards for pollution abatement are primarily in three categories: sewer systems, industrial construction, and construction by public utilities. Within each of these categories, total construction eventually is increased, as shown in table 38 and 39. For one category, sewer systems, the increase is not immediate; in fact there is a reduction in the early years, which results from unspent authorizations. There is a lag between the time when grant authorization bills are passed and the time when expenditures begin. Localities apparently postpone their own expenditures to wait for the federal matching funds.

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[1] Kenneth Leung and Jeffery Klein, "The Environmental Control Industry," December 1975; Kidder and Peabody and Co.

TABLE 36

PROJECTIONS OF INCREMENTAL PRIVATE EXPENDITURES AND FEDERAL GRANTS TO MUNICIPALITIES UNDER THE CONSTRUCTION GRANTS PROGRAM

Year	Grants authorized under 1972 Act (BASELINE)	Grants projected under assumed construction grants program (ACTUAL)	Difference	Incremental industrial expenditures (ACTUAL)
1978	3294	3333	39	4627
1979	2961	3713	752	7552
1980	2255	3650	1395	9498
1981	1431	3900	2469	10382
1982	809	4100	3291	12776
1983	497	3750	3253	14247
1984	346	3600	3254	12776
1985	231	3600	3369	13144

TABLE 37

PROJECTED TOTAL SPENDING ON CONSTRUCTION 1978-1985 (1972 dollars)

Year	BASELINE construction ($millions)	EPA mandated expenditures ($millions)	ACTUAL total construction ($millions)	Percent increase in construction	Percent displacement
1978	120959	2186	121926	0.80	1.0
1979	125619	3666	127822	1.75	1.2
1980	133484	4575	136374	2.16	1.3
1981	140773	5128	143971	2.27	1.4
1982	147605	5624	151126	2.39	1.4
1983	154524	5841	158154	2.35	1.4
1984	160900	5804	164553	2.27	1.3
1985	162058	4787	165249	1.97	1.0

TABLE 38

SEWER SYSTEM CONSTRUCTION
(millions of 1972 dollars)

Year	BASELINE	ACTUAL	Percentage Difference
1978	3587	3006	-16.19
1979	3595	3324	-7.52
1980	3528	3522	-0.18
1981	3449	3766	9.20
1982	3438	3988	15.99
1983	3502	3737	6.71
1984	3592	3925	9.28
1985	3661	4080	11.46

TABLE 39

CONSTRUCTION BY PUBLIC UTILITIES AND MANUFACTURING
(millions of 1972 dollars)

UTILITIES

Year	BASELINE	ACTUAL	Percentage Difference
1978	10080	10700	6.17
1979	10194	11312	10.97
1980	10347	11560	11.72
1981	10536	11466	8.82
1982	10735	11814	10.06
1983	10974	12199	11.16
1984	11217	12586	12.20
1985	11479	12493	8.83

MANUFACTURING

Year	BASELINE	ACTUAL	Percentage Difference
1978	9664	10808	11.84
1979	10038	11759	17.15
1980	10341	12559	21.45
1981	10988	13510	22.95
1982	11291	13834	22.52
1983	12010	14937	24.37
1984	13325	16144	21.15
1985	13930	16589	19.09

Then, when the authorizations are spent, construction receives a double impetus from the grants and the release of unspent funds by localities.

The added environmental expenditures reduce other types of construction slightly because of increases in interest rates and other construction costs. In general, the effects on other types of construction are less than 1 percent. BASELINE and ACTUAL values are shown in table 40.

THE EFFECT ON EMPLOYMENT

The percentage increase in construction employment is roughly equal to the increase in construction output. At first, employment increases less rapidly than new construction as employers increase output by using their labor force more intensively. If demand remains strong, they hire new workers. The effect on demand for labor is summarized in table 41. The increase in employment is between 30 thousand workers and 100 thousand, depending on the year. This takes account of only on-site, production workers. To estimate effects on all construction workers, the figures in table 41 should be multiplied by 1.22, the ratio of total employment to production worker employment 1972-1975. The adjusted figures are presented in table 42.

In most of the study, we consider the baseline to include the spending of grants authorized under the 1972 Act, but not grants authorized under later legislation. For comparison we also estimate the effects of the grants compared with a zero baseline, which includes no grants at all. These effects are presented in table 43 and 44. To derive these figures, we adjusted baseline employment using techniques described later in this chapter, in the impact handbook.

The added construction leads to lower unemployment in contract construction. Projections are shown in table 45.

THE EFFECT ON DEMAND FOR LABOR IN SPECIFIC TRADES

The increase in labor demand is not uniform across skill classes. Increases in employment of selected specialties in 1980 and 1983 are shown in table 46. Percentage employment increases are greatest for skills needed in industrial construction, electricians, ironworkers, and plumbers. Gains are least for crafts used

TABLE 40

PROJECTIONS OF RESIDENTIAL CONSTRUCTION, COMMERCIAL CONSTRUCTION AND STATE AND LOCAL CONSTRUCTION EXCEPT SEWER SYSTEMS (millions of 1972 dollars)

RESIDENTIAL

Year	BASELINE	ACTUAL	Percentage differences
1978	48229	48140	-0.18
1979	50691	50450	-0.48
1980	55475	50178	-0.54
1981	59065	58791	-0.46
1982	62986	62665	-0.51
1983	65969	65618	-0.53
1984	67014	66628	-0.58
1985	65237	64894	-0.53
		COMMERCIAL	
1978	14284	14219	-0.46
1979	15841	15759	-0.52
1980	18456	18315	-0.76
1981	20869	20689	-0.87
1982	23328	23110	-0.93
1983	25888	25611	-0.07
1984	28189	27849	-1.21
1985	29229	28827	-1.37
	STATE AND LOCAL EXCEPT SEWER SYSTEMS		
1978	23678	23616	-0.26
1979	23824	23781	-0.18
1980	23900	23803	-0.40
1981	24429	24312	-0.48
1982	24390	24277	-0.46
1983	24743	24614	-0.52
1984	26126	25984	-0.54
1985	27085	26929	-0.58

TABLE 41

PROJECTED CONSTRUCTION EMPLOYMENT: PRODUCTION WORKERS ONLY
(thousands of workers)

Year	BASELINE	ACTUAL	Difference[a]	Percentage Difference[a]
1978	3180	3216	36	1.14
1979	3269	3314	45	1.39
1980	3428	3501	72	2.11
1981	3631	3716	84	2.33
1982	3800	3891	92	2.41
1983	3937	4033	96	2.43
1984	4069	4164	95	2.34
1985	4127	4212	85	2.06

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[a] Difference and Percentage Difference calculated from unrounded data.

TABLE 42

PROJECTED CONSTRUCTION EMPLOYMENT: ADJUSTED TO INCLUDE ALL WORKERS IN THE INDUSTRY
(Thousands of Workers)

Year	BASELINE	ACTUAL	Difference	Percentage Difference
1978	3880	3924	44	1.14
1979	3988	4043	55	1.39
1980	4182	4271	89	2.11
1981	4430	4534	104	2.33
1982	4636	4747	111	2.41
1983	4803	4920	117	2.43
1984	4964	5080	116	2.34
1985	5035	5139	104	2.06

TABLE 43

PROJECTED EMPLOYMENT EFFECT USING ZERO BASELINE: PRODUCTION WORKERS ONLY
(Thousands of Workers)

Year	Zero BASELINE	ACTUAL	Difference	Percentage Difference
1978	3174	3216	42	1.3
1979	3257	3314	57	1.8
1980	3419	3501	82	2.4
1981	3625	3716	91	2.5
1982	3796	3891	95	2.5
4983	3935	4033	98	2.5
1984	4068	4164	96	2.4
1985	4126	4212	86	2.1

TABLE 44

PROJECTED CONSTRUCTION EMPLOYMENT EFFECT USING ZERO BASELINE: ADJUSTED TO INCLUDE ALL WORKERS IN THE INDUSTRY

(Thousands of Workers)

Year	Zero BASELINE	ACTUAL	Difference	Percentage Difference
1978	3872	3924	52	1.3
1979	3973	4043	70	1.8
1980	4171	4271	100	2.4
1981	4423	4534	111	2.5
1982	4631	4747	116	2.5
1983	4800	4920	120	2.5
1984	4963	5080	117	2.4
1985	5033	5139	106	2.1

TABLE 45

PROJECTED UNEMPLOYMENT RATE CONTRACT CONSTRUCTION

Year	BASELINE	ACTUAL	Percentage Difference
1977	14.65	14.39	-1.77
1978	17.11	16.87	-1.41
1979	17.90	17.59	-1.72
1980	14.47	14.10	-2.58
1981	11.05	10.74	-2.85
1982	9.09	8.83	-2.94
1983	7.83	7.60	-2.96
1984	6.97	6.77	-2.66
1985	7.31	7.12	-2.52

TABLE 46

EFFECT ON NATIONWIDE EMPLOYMENT BY SKILL GROUP 1980 AND 1985 (Thousands of Workers)

Effect on	BASELINE	ACTUAL	Percentage Increase
		1980	
All labor	3428	3501	2.1
Bricklayers	195	200	2.2
Carpenters	658	667	1.2
Cement Finishers	77	78	1.8
Electricians	215	223	3.8
Equipment Operators	213	214	.3
Ironworkers	102	106	3.6
Laborers	1116	1140	2.2
Other workers	494	506	2.5
Plumbers	231	239	3.4
Painters	126	127	.9
		1983	
All labor	3937	4033	2.4
Bricklayers	227	232	2.1
Carpenters	764	775	1.5
Cement finishers	88	90	2.1
Electricians	253	263	3.8
Equipment Operators	227	230	1.3
Ironworkers	118	123	4.1
Laborers	1274	1306	2.6
Other workers	569	586	3.0
Plumbers	271	280	3.4
Painters	147	148	.8

heavily in residential construction: painters, carpenters and bricklayers.

THE EFFECT ON WAGES, INTEREST RATES AND PRICES

A central question of this study was whether increased demand would serve to increase employment and output or would simply bid up wages and interest rates and the cost of new construction. Our conclusion is that it does both, but that the percentage effect on output exceeds the effect on prices.

Consider, for example, projections of average hourly earnings. These projections, adjusted to include fringe benefits, are shown in table 47. For comparison, the percentage effect on employment is shown in the last column. As can be seen, the percentage gain in employment is always at least twice as large as the rise in wages. Recall, however, that the wage increases persist even after the employment gains have passed. Current wages have a strong impact on future wages; once the wage is bid up, it is hard to push down.[1]

Because of the higher wages, prices increase slightly. The projected value of the GNP deflator for construction is shown in table 48.

The added demand for new construction induces an added demand for borrowed funds, which increases interest rates. Projected rates of interest for taxable and tax exempt bonds are shown in table 49. In most years, the

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[1] The size of wage changes may be underestimated. In our equations, environmental expenditures can push up the construction wage through only one channel, the increase in demand for labor. We suspect that there are several other mechanisms that can not be measured using national, time series data.

First, projects involving federal aid, such as those with EPA construction grants, must pay union wage rates because of the Davis-Bacon Act. Since union rates are higher than nonunion rates, they will tend to increase wage costs more than would a general rise in demand. Second, heavy demand for one craft in one region can lead to wage increases that spread to wage increases in other crafts or regions. Thus, heavy demand in one area can send a rippling effect on wages throughout the country.

TABLE 47

PROJECTIONS OF AVERAGE HOURLY EARNINGS INCLUDING FRINGE BENEFITS
(Production workers only)

Year	BASELINE	ACTUAL	Percentage difference of ACTUAL over BASELINE	Percentage employment increase
1978	9.49	9.50	0.07	1.1
1979	9.98	9.99	0.10	1.4
1980	10.47	10.48	0.14	2.1
1981	11.04	11.07	0.20	2.3
1982	11.73	11.77	0.29	2.4
1983	12.55	12.60	0.41	2.4
1984	13.52	13.59	0.57	2.3
1985	14.65	14.77	0.78	2.1

TABLE 48

PROJECTIONS OF GNP DEFLATOR FOR CONSTRUCTION

Year	BASELINE	ACTUAL	Percentage increase[a]
1978	1.57	1.57	0.07
1979	1.64	1.65	0.19
1980	1.73	1.73	0.26
1981	1.83	1.84	0.27
1982	1.92	1.93	0.37
1983	2.02	2.03	0.41
1984	2.15	2.16	0.51
1985	2.29	2.31	0.55

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[a] Calculated from unrounded data.

TABLE 49

PROJECTED INTEREST RATES

Year	BASELINE	ACTUAL	Percentage Increase
	Yield on Corporate Bonds (Moody's AAA)		
1978	8.62	8.64	0.31
1979	8.64	8.69	0.61
1980	8.80	8.87	0.75
1981	8.77	8.84	0.77
1982	8.61	8.69	0.88
1983	8.39	8.47	0.96
1984	8.26	8.34	1.04
1985	8.27	8.35	0.98
	Yield on High Grade Municipal Bonds (Standard and Poor's)		
1978	6.34	6.37	0.39
1979	6.33	6.38	0.83
1980	6.35	6.41	1.02
1981	6.39	6.45	0.99
1982	6.29	6.36	1.13
1983	6.05	6.13	1.23
1984	5.98	6.06	1.32
1985	6.04	6.11	1.20

effect of environmental programs is to raise the corporate bond rate by between .5 percent and 1.0 percent of its baseline value and raise the tax exempt (municipal) bond rate by between .5 percent and 1.2 percent.

THE EFFECT ON WORKERS OF PARTICULAR CHARACTERISTICS

The foregoing describes our results based on the analysis of time series data. Our analysis of Social Security data on individual workers allowed us to estimate effects in more detail. Specifically, we were able to break down our estimate of effects on employment into employment of workers by experience, age, locality and race. These detailed effects on employment are summarized in table 50. A further discussion is available in the Impact Handbook, the next chapter.

THE EFFECTS OF A REDUCED CONSTRUCTION GRANT PROGRAM

The actual spending under the Construction Grants program so far has fallen short of the target set in 1977, of 45 billion (1978-1987) and of the authorizations made in December 1977. Both were based on assumed expenditures of about $5 billion dollars per year. We estimated the effects of this shortfall. To represent the target level of grants we used projections from the Council on Environmental Quality made in 1976. To represent the lower levels we used our projections of ACTUAL expenditure. The difference in spending is shown in table 51. In some years, the shortfall is as great as 30 percent, resulting in 5 percent to 8 percent less sewer construction (see table 52). Sewer construction (measured in dollars) is reduced by less than the spending shortfall because of displacement (discussed in detail in chapter 2); much of the reduced federal spending is made up by increased local spending.

The effects on the construction industry as a whole are summarized in table 53. The effects on projected construction spending are small in percentage terms, primarily because sewer system construction is a modest fraction of total construction. Effects on employment are roughly in proportion to the effect on construction. Wages and prices are bid up slightly.

TABLE 50

INCREASED EMPLOYMENT OF CONSTRUCTION WORKERS DUE TO ENVIRONMENTAL EXPENDITURES BY CHARACTERISTICS OF WORKER

	1978	1985
Total	36,120	85,000
By experience		
little experience (less than one year)	11,920	28,050
some experience (1-4 years)	12,280	28,900
much experience (over 4 years)	11,920	28,050
By locality		
local workers	19,505	45,900
workers moving in	9,030	21,250
commuters	7,585	7,650
By age		
less than 24 years old	11,920	28,050
24-35	11,558	27,200
36-49	9,391	22,100
50+	3,251	7,650
By race		
white	31,063	73,100
nonwhite	5,057	11,900

TABLE 51

PROJECTED SPENDING UNDER THE CONSTRUCTION GRANTS PROGRAM
1978-1985
(millions of 1972 dollars)

Year	Higher level of grants	ACTUAL	% decrease in spending
1978	3898	3333	-14.5
1979	4518	3713	-17.8
1980	4891	3650	-25.4
1981	5052	3900	-22.8
1982	5155	4100	-20.5
1983	5235	3750	-28.4
1984	5305	3600	-32.1
1985	5355	3600	-32.8

TABLE 52

SEWER SYSTEM CONSTRUCTION
(millions of 1972 dollars)

Year	Under higher grant outlay	ACTUAL	Percentage effect
1978	3167	4006	-5.07
1979	3545	3324	-6.22
1980	3845	3522	-8.40
1981	4060	3766	-7.24
1982	4254	3988	-6.23
1983	4073	3737	-8.24
1984	4287	3925	-8.44
1985	4433	4080	-7.96

TABLE 53

PROJECTED NEW CONSTRUCTION SPENDING AND EMPLOYMENT
(in millions of 1972 dollars)

Year	Under higher grant outlay	ACTUAL	Percentage change
1978	122074	121926	-0.12
1979	120815	127822	-0.15
1980	136660	136374	-0.21
1981	144226	143971	-0.18
1982	151355	151126	-0.15
1983	158444	158154	-0.18
1984	164857	164553	-0.18
1985	165536	165249	-0.17
EMPLOYMENT: PRODUCTION WORKERS ONLY (thousands of workers)			
1978	3218	3216	-0.06
1979	3318	3314	-0.13
1980	3507	3501	-0.17
1981	3722	3716	-0.19
1982	3897	3891	-0.16
1983	4039	4033	-0.16
1984	4171	4164	-0.17
1985	4219	4212	-0.16
GNP DEFLATOR FOR CONSTRUCTION			
1978	1.57	1.57	-0.02[a]
1979	1.65	1.65	-0.02
1980	1.73	1.73	-0.04
1981	1.84	1.84	-0.04
1982	1.93	1.93	-0.04
1983	2.03	2.03	-0.06
1984	2.16	2.16	-0.06
1985	2.31	2.31	-0.07
AVERAGE HOURLY EARNINGS OF CONSTRUCTION WORKERS INCLUDING FRINGE BENEFITS			
1978	9.50	9.50	-0.00[a]
1979	9.99	9.99	-0.00
1980	10.48	10.48	-0.01
1981	11.07	11.07	-0.01
1982	11.77	11.77	-0.02
1983	12.61	12.70	-0.03
1984	13.60	13.59	-0.04
1985	14.77	14.77	-0.05

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[a] Calculated from unrounded data

The major objective of this study was to estimate the effects of environmental expenditure that have been mandated by Federal environmental grants and regulations. The purpose of this handbook is to generalize these results, to provide the basic data for estimating the effects of environmental programs of other sizes. In our earlier calculations of the effect of environmental expenditure, we estimated the effects of construction grants and industrial abatement expenditures, taken together. For the present purpose, we need to separate the effects of these two programs. Separate estimates are presented for $1 billion under the construction grants program and $1 billion of expenditure by manufacturing industries. The effects that correspond to these expenditures of $1 billion can then be rescaled to estimate the effects of alternate programs.

This technique of estimation is not precise, but it does give an indication of what could be expected from alternate programs. The technique would be completely accurate if our model were perfectly linear.

EFFECTS OF CONSTRUCTION GRANTS

We turn first to our estimates of the effects on the construction industry as a whole. The effects of a $1 billion annual increase in the construction grants program for each of 8 years, 1978-1985, are presented in table 54 and described in more detail in the following text. Table 55 provides further detail on employment. Table 56 and the following text provide similar information for industrial expenditures. Finally, we present the estimates of effects on workers with specified characteristics.

Effect on Sewer System Construction

Construction grants concentrate their effects on sewer system construction. One billion dollars of extra grants per year generates $285 million of expenditure on sewer system construction in the first year (the short-run effect) and $465 million in the eighth year (the long-run effect).

These increases are much less than the full $1 billion for several reasons. One reason is that 15 percent to 20 percent of construction grants expenditure is for equipment not construction.

TABLE 54

EFFECTS OF $1 BILLION ANNUAL CONSTRUCTION GRANTS

Effect on	Increase	Increase as a % BASELINE
Sewer system construction in first year (1978)	$285M	(5.6%)
Sewer system construction in eighth year (1985)	465M	(4.1%)
Total construction in first year	268M	(.12%)
Total construction in eighth year	444M	(.08%)
Employment in first year	1950*	(.06%)
Employment in eighth year	2920*	(.07%)
Employment in year of peak effect	4490*	(.12%)
Wages second year		.002%
Wages eighth year		.03%
Interest rates second year		.03%
Interest rates eighth year		.04%
Capital costs first year		.02%
Capital costs eighth year		.04%

*Workers

TABLE 55

EFFECTS OF $1 BILLION ANNUAL CONSTRUCTION GRANTS ON EMPLOYMENT BY YEAR (Thousands of Workers)

Year	BASELINE	$1 billion above BASELINE	Difference	Percentage Difference
1978	3216	3218	1.95	.06
1979	3314	3318	3.90	.12
1980	3501	3505	4.20	.12
1981	3716	3720	4.46	.12
1982	3891	3896	4.49	.12
1983	4033	4036	3.72	.09
1984	4164	4167	3.04	.07
1985	4212	4215	2.92	.07

TABLE 56

EFFECTS OF $1 BILLION ANNUAL EXPENDITURE FOR ABATEMENT OF INDUSTRIAL POLLUTION

Effect on:	Increase	(%)
Total construction:		
first year (1978)	$570 million	(.3)
eighth year (1985)	$650 million	(.17)
Employment in contract construction:		
first year	4,670 workers	(.15)
eighth year	5,520 workers	(.13)
Industrial construction	9,690 workers	(.29)
first year	$614 million	(3.7)
eighth year	$681 million	(1.8)
Wages in contract construction:		
second year		.004
eighth year		.07
Interest rates: second year		.08
Interest rates: eighth year		.07
Capital costs of new manufacturing plants: second year		2.5
Capital costs of new manufacturing plants: eighth year		2.5

Displacement

A second reason is displacement: communities respond to grants by reducing expenditures from their own funds. This reduction, which was estimated as part of the model, takes two forms. Short-run displacement refers to the reduction of the community's expenditure in hopes of a grant later and, for a community that receives the grant, postponement of construction to match the pattern of outlays for the grants. Permanent displacement (which we estimate at 52 cents per dollar) refers to a long-run reduction in local construction in response to grants, possibly because the grants pay for some of the same facilities the community would have built on its own. The extent of this permanent displacement will govern the long-run effect of construction grants on sewer system construction.

Effect on Total Construction

One billion dollars of construction grants expenditure translates into $268 million in total construction expenditures in the first year (1978) and $444 million in the eighth year (1985). These are slightly less than the effects on sewer system construction because of slightly reduced demand for other types of construction due to the increase in interest rates, and increases in other construction costs.

Employment

The percentage effect on employment is roughly the same at both the beginning and the end of the eight year period (.06 percent and .07 percent), but it is almost twice as great (.12 percent) in some of the middle years. This results from two trends operating in opposite directions. Labor demand does not respond immediately to output changes, so the effects of the added demand take several years to be fully realized. In the other direction, inflation erodes the real value of the $1 billion annual grant. The absolute increase in employment is about 2000 workers in the first year (1978), about 3000 workers in the eighth year and about 4,490 in the year of greatest effect, the fourth year (1982).

Effect on Wages, Interest Rates, and Building Costs

The grants lead wages to increase by .002 percent in the second year (there is no effect in the first year) and .03 percent in the eighth year. Interest rates are bid up .03 percent in the second year and .04 percent by the eighth year. As a consequence the annualized capital cost of a new structure (interest plus depreciation) is increased .02 percent in the second year and .04 percent in the tenth year.

An Example

Before going on, it may be useful to go through an example of how one can estimate the effects of an increase of grants other than $1 billion annually. Suppose, for instance, it was desired to estimate the effect of an increase in grants of $1.7 billion. The effects presented in table 54 would be multiplied by 1.7, e.g., total employment in the first year increases by 1.7 (1950) = 3,315 workers.

EFFECTS OF EXPENDITURES FOR ABATEMENT OF INDUSTRIAL POLLUTION

The effects of $1 billion of expenditure for pollution abatement in manufacturing are summarized in table 56. Further detail for employment is given in table 57. These figures can be adjusted for increases of industrial expenditure for pollution abatement other than 1 billion in the same way as described in the example above for grants. Further, the effects of an increase in industrial expenditure (from table 56) can be added to the effects of an increase in industrial expenditure. For instance, a $1.3 billion increase in industrial expenditure along with a $1.7 billion increase in construction grants leads to an estimated increase in employment of 1.7 x 1950 + 1.3 x 4,670 = 9,386 workers.

Effects on Total Construction

Total construction rises by $570 million in the first year and $650 million in the eighth year. The increase is less than $1 billion because part of the expenditure is used for abatement equipment rather than structures (about 20 percent), and part of the construction expenditure displaces other spending on construction.

Effect on Employment

Employment rises by about 4,700 workers in the first year and 5,500 workers in the eighth year. Industrial spending on pollution abatement involves less displacement than an equivalent expenditure on construction grants so the increase in employment per billion dollars is greater.

TABLE 57

EFFECTS OF $1 BILLION ANNUAL INDUSTRIAL ABATEMENT EXPENDITURE ON EMPLOYMENT BY YEAR
(Thousands of Workers)

Year	BASELINE	$1 billion above BASELINE	Difference	Percentage Difference
1978	3216	3321	4.67	.15
1979	3314	3324	9.68	.29
1980	3501	3510	9.24	.26
1981	3716	3725	9.22	.25
1982	3891	3900	9.06	.23
1983	4033	4041	7.99	.20
1984	4164	4171	6.74	.16
1985	4212	4218	5.52	.13

*Difference and percentage difference from unrounded data.

Effect on Industrial Construction

Industrial construction is increased by $614 million dollars in the first year and $681 million dollars in the eighth year. These are less than the full expenditure because of a reduction in industrial construction for expansion of capacity. The primary cause of the reduction is the direct increase in building costs due to the requirement of pollution abatement expenditure.

Effects on Wages, Interest Rates and Capital Costs

Wages are bid up .002 percent in the second year and .03 percent by the tenth year. Interest rates are increased .08 percent in the second year, .04 percent in the eighth year. In addition, the requirement of added expenditure adds directly to the cost of a new plant so that capital costs rise by 2.5 percent.

EFFECTS ON EMPLOYMENT OF SPECIFIC GROUPS OF WORKERS

A sample of earning records for individual workers, from Social Security data, allows us to estimate the effects of major construction projects in SIC 162 (which includes sewer lines and treatment plants) on workers of differing characteristics: experienced or inexperienced, young or old, white or nonwhite, and workers moving into a labor market from other areas or local workers. Table 58 summarizes how an increase in employment of 100 workers is split between workers of different characteristics. This table allows users of this report to disaggregate any estimates of employment effects, from this study or from elsewhere. From the table it is apparent that about one-third of the increase in employment is made up of inexperienced workers, just over half of the employment gain is accounted for by local workers, about one-third is accounted for by very young workers and about 14 percent is accounted for by nonwhites.

In table 59, we present the estimated effects of $1 billion dollars (annually) of construction grants expenditure on workers of specific characteristics, and in table 60, we present equivalent estimates for $1 billion of industrial expenditure. These estimates are based on the total employment effects estimated from the time-series model and on the estimates of how a gain in employment is split between workers of different characteristics (from table 58).

TABLE 58
HOW 100 NEW JOBS WOULD BE DISTRIBUTED AMONG DIFFERENT TYPES OF WORKERS

By experience:	
little experience (less than one year)	33
some experience (1-4 years)	34
much experience	33
Total	100
By locality	
local workers	54
workers moving in	25
commuters	21
Total	100
By age	
less than 24 years old	33
24-35 years old	32
36-49 years	26
50+	9
Total	100
By race	
white	86
nonwhite	14
Total	100

TABLE 59

EFFECTS OF AN ADDED $1 BILLION ANNUAL CONSTRUCTION GRANTS EXPENDITURE

	year 1	year 8
Total employment (from table 54)	1950 workers	2920 workers
By experience:		
little experience (less than	644	964
some experience (1-4 years)	662	992
much experience (over 4 years)	644	964
By locality		
local workers	1053	1577
workers moving in	488	730
commuters	409	613
By age		
less than 24 years old	644	964
24-35 years	624	934
36-49 years	507	959
50+	175	263
By race		
white	1677	2511
nonwhite	273	409

TABLE 60

EFFECTS OF AN ADDED $1 BILLION INDUSTRIAL ABATEMENT EXPENDITURE

	year 1	year 8
Total employment (from table 56)	4670 workers	5520 workers
By experience		
little experience (less than one year)	1541	1822
some experience (1-4 years)	1588	1876
much experience (5 or more years)	1541	1822
By locality		
local workers	2522	2981
workers moving in	1168	1380
commuters	981	1160
By age		
less than 24 years old	1541	1822
24-35 years	1494	1766
36-49 years	1214	1435
50+	420	496
By race		
white	4016	4747
nonwhite	654	773

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